# Contagious Bovine Pleuropneumonia in Pastoralist Areas of East Africa: Disease Dynamics and Control Options

African Union/Interafrican Bureau for Animal Resources

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## Abbreviations and Modelling Symbols

| | |
|---|---|
| $\alpha$ | recovery rate |
| AHSP | Animal Health Services Project |
| BEF | bovine ephemeral fever |
| CAPE | Community-based Animal Health and Participatory Epidemiology Unit, AU/IBAR |
| CBPP | contagious bovine pleuropneumonia |
| CFT | complement fixation test |
| ELISA | enzyme linked immunosorbent assay |
| FAO | Food and Agriculture Organization |
| FMD | foot-and-mouth disease |
| HS | hemorrhagic septicaemia |
| $\kappa$ | sequestra re-activation rate |
| MOU | memorandum of understanding |
| PACE | Pan African Programme for the Control of Epizootics, AU/IBAR |
| PPR | peste des petits ruminants |
| $R_o$ | basic reproductive number |
| RP | rinderpest |
| SE | stomatitis enteritis |
| $\sigma$ | CBPP-specific mortality rate |
| VSF | Veterinaires sans Frontieres |

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## SUMMARY

This report describes the results of a participatory epidemiological study into the epidemiology of contagious bovine pleuropneumonia (CBPP). The purpose of the study is to gather first hand expert opinion on the epidemiology of CBPP as it occurs in pastoral areas. This information will be used in formulating parameter estimates for epidemiologic modelling using a state transition design. Existing veterinary knowledge of livestock owners is a key resource that ensures the relevance and realism of disease models. Considerable information was also gathered on the traditional community structure and the level and types of contact between groups. This information will assist in model development for CBPP.

This report covers the following missions:

- four weeks in Boma, Southern Sudan,
- a short preliminary site visit to the Mwanza area in Tanzania and
- a three week mission to Meatu and Tarime, Tanzania.

In Boma, the study focused on the four clans of the Jie in their villages and at their cattle camps along the Kengen and Bodo Rivers. Additional participatory assessments were carried out with the Murle, Kachipo and displaced Dinka in the area. All of these groups interact. The Murle were located at their dry season grazing area in Lazach.

In Mwanza, participatory assessments were completed with the mixed agricultural Wasukuma in Kwimba and with the pastoral Tatuga in Meatu District. Although the Wasukuma are adopting agriculture, they continue to maintain large cattle herds and cattle play an important role in culture. The Tatuga are a primarily pastoral culture closely related to the Maasai.

The methodology used throughout the study was participatory epidemiology. This technique involves the use of participatory methods to gather intelligence on the epidemiology of disease. The process began with semi-structured interviews using open-ended questions. Typically respondents were asked to describe their cattle disease problems. Issues raised by the informants were probed. Once CBPP was volunteered as a problem, the interview team conducted more detailed data collection exercises on this disease. These included mapping, matrix scoring, timelines and proportional piling activities.

Approximately 1,400 sera were collected and tested for CBPP antibodies using the CFT and ELISA test. The CBPP test results will be used to estimate prevalence and to assist in the estimation of the basic reproductive number ($R_0$) for CBPP for the disease modelling.

In the course of conducting this study, several agencies requested input on how best to serve farmers needs in regard to CBPP control given the current state of knowledge, available tools and limited resources. The recommendations provided in the report are not conclusions. They are best-bet scenarios to guide current action in the field.

The one main conclusion of this study is that treatment is a much more commonly practiced intervention than vaccination. It is also widely perceived in the field as beneficial if not essential. A technically sound control programme based upon treatment or treatment and vaccination would be well adapted to the current socio-economic climate of the liberalization and privatisation of animal health supplies and services. However, the impact of treatment, positive or negative, has never been adequately documented in controlled studies. Treatment protocols warrant at least as much attention in research agendas as vaccine development.

## Part One: Studies in Boma, Southern Sudan

### 1.1 Contagious bovine pleuropneumonia

#### 1.1.1 Interim best-bet interventions for the control of CBPP

As this study was not primarily a needs assessment, disease problems were not directly ranked. *Louko* was invariably mentioned as a major disease concern in each interview. In the matrix scoring exercises, respondents were asked to rank the importance of four diseases (CBPP, RP, trypanosomiasis, and fascioliasis) for the dry and rainy seasons. Contagious bovine pleuropneumonia ranked first in the dry season and second in the rainy season. Any programme seeking to address the perceived animal health needs of the communities around Boma will need to address *louko* as a major priority.

Considering the impact, endemic nature and the difficulty of elimination by accepted methods of CBPP control, we recommend that programs should focus on realistic elective control methods that reduce overt losses. We would like to suggest that CAHW networks be trained and equipped to administer treatment and preventive vaccination at the livestock owner's request and upon payment. Unless evidence is produced that documents untoward effects of treatment in the context of an elective impact mitigation policy, treatment should be available for severe cases in order to reduce mortality. For the present, antibiotics such as long acting tetracyclines, tylosin and its relatives can be provided with appropriate training on their proper application.

Further evaluations of the use of antibiotics in a field setting should be undertaken simultaneously. The Dinka cattle camp in Boma may offer an excellent opportunity to evaluate antibiotics. The camp is located in the centre of town. These cattle are readily accessible to NGO staff and kept under more or less traditional management conditions. Representative cases could be treated and monitored for clinical response. At the end of the period of observation, a subset could be purchased for post-mortem examination and culture of sequestra.

Vaccination can be provided to animals and herds in contact or at risk of exposure using market-based pricing. The limitations and extent of the duration of immunity should be clearly explained to livestock owners as part of the service.

Action research on a tactic of combined vaccination and treatment vs. simple vaccination on a herd basis would also be worthwhile. Of course, it is pointless to vaccinate animals undergoing treatment. The tactic would consist of treatment of clinical cases and simultaneous vaccination of others in contact. Treatment should constitute a course of three injections of long acting tetracyclines until specific research substantiates a better treatment alternative. Serological tests for CBPP (CFT and C-ELISA) detect active infection and about 70% of infected sequestra. Vaccinal antibodies do not persist for more than 12 weeks. Impact of a vaccination and treatment could be evaluated by pre-intervention and 12-weeks post-intervention serological evaluation of the herds under the two different regimes. The impact of each respective tactic on the number of serological reactors could be taken as a measure of suppression of infection.

#### 1.1.2 An overview of the Jie definition of *louko*

The Jie term *louko* describes a respiratory disease with the following clinical course:

- fever
- depression

- coughing
- dilated nostrils
- dyspnoea
- jugular pulse
- anorexia
- loss of weight
- death

Fever is not constantly reported. Depression and respiratory signs are the most frequently noted initial signs. Herders note that the lungs are firm and adhered to the chest wall in animals that succumb or that are slaughtered in advanced stages.

Livestock owners, when asked to describe the disease, frequently act out the respiratory distress with associated noises, stance and flaring of the nostrils. Typical cases presented by the herders demonstrated this characteristic appearance together with a jugular pulse readily detectable at a distance. Post mortem examination of a representative case revealed marbling of lungs and well-developed fibrinous adhesions between the lungs and the chest wall. Samples submitted for histopathology were consistent with a diagnosis of contagious bovine pleuropneumonia.

Mild cases are recognised, but the term *louko* usually brings to mind acute severe disease. It is only on probing that one finds a spectrum of severity and duration. Death may occur within one week to one year of the onset of symptoms.

Although *louko* can affect any age animal, calves, heifers and young bulls are most commonly affected groups. All informants uniformly reported that *louko* can only affect an animal once in its life. Older animals have presumably survived an earlier episode.

The severity of disease varies from year to year, but 'it is always present.'

The Jie described *louko* as a disease spread by contact or shared watering points.

The Jie report that the disease is seasonal in severity and that the source of disease is 'our own herds.' They report that stress exacerbates the disease and that the most severe cases occur in the rainy season. Acute cases can partially recover and linger for up to one year. The primary symptoms of chronic cases are poor condition and chronic cough.

Although the availability of antibiotics is limited, the Jie treat *louko* with antibiotics and report that antibiotics save lives. However, the antibiotics available were mainly capsules that they dissolved in water before injecting. Descriptions of treatment made it clear that under-dosing was common. They did not report any experience with vaccination. Beyond documenting the livestock owners' strong impression that treatment saved lives, this study did not investigate the impact of treatment.

### 1.1.3 Some insights from matrix scoring

Matrix scoring is useful as a technique to confirm verbal descriptions provided in interviews and to delve more deeply into shades of meaning and extent or importance of different characteristics.

The study team prepared cards representing four diseases and a series of disease symptoms and risk factors. The cards representing diseases were prepared using drawings from CAHW manuals. Each disease card was passed to the respondents who had no difficulty in identifying the disease represented without any prior information other than the statement that the card represented a disease. The four disease cards were then arranged in a column as heads of rows. One symptom card was passed around and the meaning of the card discussed. Some were self-explanatory whereas others required additional information. Once everyone was aware of the meaning, the symptom card was placed at the head of a new column and the respondents were asked to divide 10 beans between the four disease rows. If the symptom was not associated with any of the four diseases, the respondents were told not to place any beans in the column.

After 10 symptoms were completed, the exercise was discussed and probing questions were asked about the results. The exercise was then repeated with the five cards representing risk factors. The results are presented Tables 1 and 2. The results indicate that the herders had a good clinical appreciation for the presentation of the four diseases and insight into their mode of transmission. They clearly distinguished between those diseases with a direct mode of transmission and those associated with ecologic conditions.

The classic pose of an animal in respiratory distress due to CBPP was identified as HS by herders rather than CBPP. This was the case for both drawings of the symptom and an actual, classic photo of CBPP. The herders had no trouble in describing the disease and mimicking the symptoms of CBPP. Further, they recognize the actual cases in the herd. This experience illustrates the difficulty of using photos alone and highlights the importance of using multiple methods in participatory disease searching.

At the end of this process, both the respondents and the research team had a deeper appreciation for the field presentation and dynamics of the four diseases.

In order to have an indication of the mortality due to *louko*, the respondents were asked to divide a pile of beans into four groups representing the age categories they recognized in their herds. The categories were calves, weaners, heifers and bulls, and cows. They were then asked to take away beans from the four piles representing mortality due to specific diseases during the course of the year. The results of a typical exercise are illustrated in Table 3.

### 1.1.4 Duration of infection

Initially respondents usually volunteered that *louko* is an acute, highly fatal disease. However, piling exercises revealed that a large number of cases survive the acute phase. For example, when one group was asked to divide a pile of beans into those that die from acute CBPP and those that survive the acute phase the result was that 11 would die within a month and 16 would survive beyond the month. Upon probing the results the herders noted that some of the acute cases would die within 5 days. On the other hand, of the 16 that survived beyond one month, a further five would eventually die. These deaths could occur at 2, 3, 6 or even 12 months later. In subsequent exercises, respondents were asked to divide piles of beans according those that recover and those that die. Next they were to sub-divide one of the piles. For the results shown in Table 4 the respondents were asked to sub-divide the deaths into piles representing the time until death. The participants set the time categories for the exercise to avoid the risk of leading them to overemphasis the chronic nature of the disease. For the exercise shown in Table 5, for the most part respondents were asked to divide the survivor pile to illustrate the duration of coughing as an indicator of the persistence of clinical illness. Obviously, the Jie recognize the full range of time course for CBPP from per acute to chronic. Although undoubtedly some mild manifestations of the disease are missed, the Jie recognized subtle forms of the disease. It is also noteworthy that the mature youth who are primarily responsible for the day-to-day care of the cattle were able to communicate the most subtle and detailed information about *louko*.

**Table 1: Matrix Scoring of Ten Clinical Symptoms against Four Major Diseases**

| ***Jie Group 1*** | *Ouko or Nyaouko* | *Akipi* | *Amany or Nyamany* | *Acheke or Achoke* |
|---|---|---|---|---|
| Cough | 6 | 2 | 2 | 0 |
| Diarrhoea | 0 | 0 | 0 | 10 |
| Weight Loss | 1 | 8 | 0 | 1 |
| Lachrymation | 0 | 2 | 3 | 5 |
| Swelling of Joints | 0 | 10 | 0 | 0 |
| Dilated Nostrils | 10 | 0 | 0 | 0 |
| Mouth Lesions | 0 | 0 | 0 | 0 |
| Foot Lesions | 0 | 0 | 0 | 0 |
| Fever | 10 | 0 | 0 | 0 |
| Dyspnoea | 8 | 0 | 2 | 0 |
| ***Jie Group 2*** | *Ouko or Nyaouko* | *Akipi* | *Amany or Nyamany* | *Acheke or Achoke* |
| Cough | 10 | 0 | 0 | 0 |
| Diarrhoea | 0 | 0 | 0 | 10 |
| Weight Loss | 0 | 0 | 10 | 0 |
| Lachrymation | 0 | 0 | 0 | 10 |
| Swelling of Joints | 0 | 0 | 0 | 0 |
| Dilated Nostrils | 5 | 0 | 5 | 0 |
| Mouth Lesions | 0 | 0 | 0 | 10 |
| Foot Lesions | 0 | 0 | 0 | 0 |
| Fever | 10 | 0 | 0 | 0 |
| Dyspnoea | 0 | 0 | 0 | 0 |
| ***Dinka Group*** | *Abut pio* | *Luach* | *Achom* | *Nyanatek* |
| Cough | 10 | 0 | 0 | 0 |
| Diarrhoea | 0 | 2 | 4 | 4 |
| Weight Loss | 2 | 2 | 4 | 2 |
| Lachrymation | 0 | 2 | 0 | 8 |
| Swelling of Joints | 0 | 0 | 0 | 0 |
| Dilated Nostrils | 10 | 0 | 0 | 0 |
| Mouth Lesions | 0 | 0 | 0 | 10 |
| Foot Lesions | 0 | 0 | 0 | 0 |
| Fever | 0 | 10 | 0 | 0 |
| Dyspnoea | 0 | 0 | 0 | 0 |
| ***Average*** | CBPP | Tryps | Flukes | RP |
| Cough | 8.7 | 0.7 | 0.7 | 0.0 |
| Diarrhoea | 0.0 | 0.7 | 1.3 | 8.0 |
| Weight Loss | 1.0 | 3.3 | 4.7 | 1.0 |
| Lachrymation | 0.0 | 1.3 | 1.0 | 7.7 |
| Swelling of Joints | 0.0 | 3.3 | 0.0 | 0.0 |
| Dilated Nostrils | 8.3 | 0.0 | 1.7 | 0.0 |
| Mouth Lesions | 0.0 | 0.0 | 0.0 | 6.7 |
| Foot Lesions | 0.0 | 0.0 | 0.0 | 0.0 |
| Fever | 6.7 | 3.3 | 0.0 | 0.0 |
| Dyspnoea | 2.7 | 0.0 | 0.7 | 0.0 |

Notes for Table 1

*Louko* was associated with fever, dilated nostrils, coughing and by one group with dyspnoea. The second Jie group said dyspnoea was primarily associated with *loprotoi* (HS). When the group was shown a photograph of a cow in respiratory distress from the FAO *Recognizing CBPP* manual, they identified the disease as HS. Interestingly, the first Jie group did not perceive mouth lesions as part of *acheke*. This agrees with interview data where mouth lesions are only intermittently described as part of *acheke*. The average scores for the three groups fit with textbook descriptions for the four diseases.

**Table 2: Matrix Scoring of Five Risk Factors against Four Major Diseases**

| ***Jie Group 1*** | *Ouko or Nyaouko* | *Akipi* | *Amany or Nyamany* | *Acheke or Achoke* |
|---|---|---|---|---|
| Dry Season | 1 | 8 | 0 | 1 |
| Rainy Season | 2 | 6 | 0 | 2 |
| Biting Flies | 0 | 5 | 5 | 0 |
| Swamps | 0 | 4 | 6 | 0 |
| Contact | 5 | 0 | 0 | 5 |
| ***Jie Group 2*** | *Ouko or Nyaouko* | *Akipi* | *Amany or Nyamany* | *Acheke or Achoke* |
| Dry Season | 10 | 0 | 0 | 0 |
| Rainy Season | 4 | 3 | 3 | 0 |
| Biting Flies | 0 | 5 | 5 | 0 |
| Swamps | 0 | 5 | 5 | 0 |
| Contact | 5 | 0 | 0 | 5 |
| ***Dinka Group*** | *Abut pio* | *Luach* | *Achom* | *Nyanatek* |
| Dry Season | 3 | 2 | 3 | 2 |
| Rainy Season | 3 | 2 | 2 | 3 |
| Biting Flies | 0 | 10 | 0 | 0 |
| Swamps | 3 | 3 | 4 | 0 |
| Contact | 5 | 0 | 0 | 5 |
| ***Average*** | CBPP | Tryps | Flukes | RP |
| Dry Season | 4.7 | 3.3 | 1.0 | 1.0 |
| Rainy Season | 3.0 | 3.7 | 1.7 | 1.7 |
| Biting Flies | 0.0 | 6.7 | 3.3 | 0.0 |
| Swamps | 1.0 | 4.0 | 5.0 | 0.0 |
| Contact | 5.0 | 0.0 | 0.0 | 5.0 |

Notes for Table 2

Overall the respondents clearly recognized that *louko* (CBPP) and *acheke* (RP) are associated with contact between animals. Trypanosomiasis and flukes were associated with swamps and the presence of biting flies. As the respondents were asked to divide the ten beans between the four diseases within a season, the seasonal data should be interpreted as the relative importance of disease within a season. From this perspective *louko* (CBPP) ranks first in the dry season and second in the rainy season after trypanosomiasis. The second Jie group gave a score of 10 to *louko* in the dry season and 4 in the rainy season. They explained that although *louko* is more severe in the rainy season, yet it is more common in the dry season. This one high dry season score influenced the average score.

**Table 3: Proportional piling on herd structure and disease mortality**

| | Calves | Weaners | Heifers | Cows | Total |
|---|---|---|---|---|---|
| | 10 | 12 | 13 | 32 | 67 |
| *Akipi* | 2 (20%) | 3 (25%) | 2 (15%) | 7(22%) | 14(21%) |
| *Louko* | 2 (20%) | 4 (33%) | 6 (46%) | 9(28%) | 21(31%) |
| *Amany* | 2 (20%) | 2 (18%) | 1 (8%) | 8(25%) | 13(19%) |
| Overall | | | | | 48(71%) |

Notes for Table 3

Although overall composite mortality indicated is extremely high the results indicate that *louko* is causing mortality on a level at least comparable with trypanosomiasis (*akipi*) and fascioliasis (*amain*). The age result suggests that *louko* is of greatest concern in the two categories: weaners and heifers. These are animals approximately 1 to 4 years old. The respondents noted *amany* was an important disease because it killed adults.

**Table 4: Ngiseria youth at Nawipuru: mortality due to CBPP in 35 Cases**

| Outcome | Recover | Succumb | | | |
|---|---|---|---|---|---|
| | | 10 days | 1 month | 3 months | 6 months |
| No of Beans | 10 | 8 | 7 | 3 | 7 |

Notes for Table 4

The youth explained that *louko* came with the onset of the rains and that the increase in mortality at 6 months coincided with the added stress of the dry season.

**Table 5: Survival and duration of clinical illness**

| Duration of Coughing (months) | 1 | 2 | 3 | 6 | 12 |
|---|---|---|---|---|---|
| Nyamakadol Youth | 16 | 4 | 3 | 2 | 1 |
| Bodo Elders | 2 | 3 | 4 | 4 | 4 |
| Nyamakadol Sultan Lowi Amura | 16 | NA | NA | 6 | 5 |

Notes for Table 5

The youth indicated that 26 of 44 head would survive in an initial piling exercise. The Bodo elders indicated that 17 of 33 would survive. The results shown above are the duration of coughing in the survivors. It was stated that clinical illness could persist for up to one year and that stress could exacerbate chronic cases. The Sultan did not indicate relative mortality data but indicated the duration of illness in 22 survivors using three time periods.

## 1.2 Overview of Jie disease terminology

As the interview method began with open-ended questions on general disease problems followed by probing of priorities mentioned by the community, information was gathered on a variety of disease problems. The most common disease terms mentioned by the Jie are presented in Table 6. Many other diseases are recognized by the Jie, but were not explored in detail.

The Jie also have non-specific, symptomatic terms such as diarrhoea and fever. These were useful in probing about RP and CBPP respectively. A few important general terms are provided in Table 7.

**Table 6: Jie disease nomenclature**

| Jie Disease Name | Western Name | Description |
|---|---|---|
| *Amany (liver)* | fascioliasis | • swollen gall bladder<br>• white spots in liver filled with water<br>• common during rainy season |
| *Ouko (lung)* | CBPP | • fever and jugular pulse<br>• head down<br>• tachypnoea and dyspnoea<br>• coughing<br>• dilatation of nostrils<br>• severe cases stop coughing and grazing<br>• lungs swollen, hard and stuck to ribs<br>• always present but sometimes worse than others |
| *Etid (spleen)* | | • splenomegaly<br>• death<br>• different from *akolokan*<br>• doesn't affect people |
| *Akolokan* | anthrax | • swollen spleen<br>• sudden death<br>• affects people |
| *Lokwas* | blackquarter | • swollen leg<br>• death in two days |
| *Loprotoi* | HS | • starts with swollen tongue<br>• swollen neck<br>• death in two days<br>• rainy season |
| *achoke, acheke* | RP | • water from eyes<br>• skin rash<br>• green diarrhoea<br>• bloody diarrhoea in calves<br>• not only calves, adults not previously infected<br>• like *hisbah* (measles), can only get it once |
| *Apid (gall bladder)* | anaplasmosis | • swelling of gall bladder |
| *Ataptap* | FMD | • sores on feet and mouth |
| *Akipi* | trypanosomiasis | • chronic weight loss despite grazing<br>• tissues oedematous – 'disease of water'<br>• loss of tail hair<br>• caused by *rakaurorot* (tabanids) |
| *Akumol* | Chronic FMD | • seeks shade<br>• long hair coat<br>• unthrifty |

**Table 7: Jie Terminology**

| Jie Term | English Translation |
|---|---|
| *Aram* | diarrhoea |
| *aram akokwo* | bloody diarrhoea |
| *aram nyakapi* | watery diarrhoea |
| *Manakwan* | fever (breathing fast and hot to touch) |
| *Ngisiru* | mosquitoes |
| *Rakaurorot* | tabanids |

## 1.3 Jie community structure and relationships with neighbouring communities

The Jie are divided into four clans: Nyiresa, Tarakabon, Nyamakadol, and Nyakurunu. Each clan has a chief. Traditionally, the Jie do not have a paramount chief over all four clans. The authorities in Boma and Pibor have appointed paramount chiefs for administrative purposes. For this reason, the chief of the Nyiresa at Nawipuru has been appointed as chief of all Jie from the southern sector perspective. A different paramount chief and at least some different clan chiefs are recognized in Pibor

Jie elders meet at places called *etam*. In the afternoon, these are usually under large trees, but in the evening open places in the centre of the village also serve as meeting points. Interviews with elders were often completed at these locations.

The relative size of the clans and the relationship between the clans and surrounding communities was explored in interviews, ranking exercises, Venn diagramming and by direct observation. Key results are summarized in Table 8.

The Tarakabon were the most remote group. Coming from Lopet, they had limited contact with Boma and actually had more interaction with the Toposa than with the other Jie clans. In terms of RP vaccination coverage, this was the most poorly covered clan. They probably also form the most direct link between the Pibor Murle and Massingo Toposa.

Examples of Venn diagramming are presented in Figures 1 to 3. The size of circles represents the relative size of the social group. The amount of overlap represents the degree of friendly interaction between groups (excluding raiding).

In Figure 1, the relationship between the four clans is illustrated. Note that all four clans have contact, but that the Nyakurunu and Nyiresa have a very close relationship. The Tarakabon and Nymakadol also interact more closely with each other than with the Nyiresa and Nyakurunu. The Tarakabon had the least interaction with the Nyiresa.

In Figure 2, the relationships between the Jie and three neighbouring tribes: the Murle, Toposa and Kachipo are presented. The diagram highlights the central position of the Jie in the interactions between the Murle, Toposa and Jie. This is the Jie's perspective, but it was largely supported by direct observation and discussions with other groups.

Diagrams were also made showing the relationship between the four clans and the three neighbouring tribes. These provide more information, but are less easily read due to the large number of interlocking circles (Figure 3). These diagrams showed that the Nyiresa and Nyakurunu had a close relationship with the Kachipo. The Kachipo have extensive contact with the agricultural Murle, but this group was not included in the diagrams and maps as they own almost no cattle. The Tarakabon Jie had the closest relations with the Massingo Toposa. The Pibor Murle primarily interact with the Nyamakadol Jie.

A detailed map was also made of the areas covered by the four clans, Toposa, Murle and Kachipo. This map agreed closely with the Venn diagrams including the relative lack of direct, routine contact between the Toposa, Murle and Kachipo.

The short-term types of cattle contact such as shared grazing and watering points are of interest in regard to acute infections such as RP. Population migration between herds and communities is perhaps more important for a chronic disease such as CBPP. Cattle interchange through exchange, loan and dowry were important forms of population migration between groups. Respondents noted that a dowry of about 40 animals was usually divided between family members and multiple herds. In some preliminary wealth ranking work, herders identified daughters as a major source of wealth. Having many sons and few daughters was viewed as a sign of difficulty. Most herds received and lost animals through dowry and other exchanges several times a year. For a chronic disease such as CBPP, this should be considered as a major mechanism of dissemination that contributes to a more uniform distribution throughout the community than might otherwise be expected.

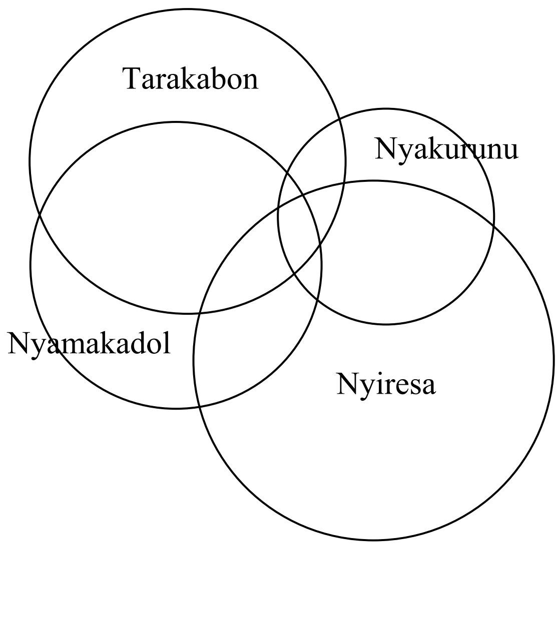
**Table 8: The Jie Clans**

| Name | Homestead | Grazing Area | Derivation of Name | Order of Contact |
|---|---|---|---|---|
| 1. Nyiresa | Nawipuru | Kanamuge | Leopard | 4, 3, 2 |
| 2. Tarakabon | Lopet | Kengen/Kanamuge | Hyena | 3, 1, 4 |
| 3. Nyamakadol | Lopet/Maroua | Kengen/Kanamuge | Loin Cloth | 2, 1, 4 |
| 4. Nyakurunu | Romut | Losidok | Ash | 1, 3, 2 |

Notes for Table 8

The clans are listed in order of size. All interviews agreed as to the relative size of the clans. Remarkably, the respective clans all ranked their level of contact with other clans in a consistent manner. Note that the Nyamakadol interviewed were from Lopet and Maroua. Other groups come down from the direction of Pibor, but were not interviewed. The Tarakabon noted that they had more contact with non-Jie such as the Massingo Toposa and Murle of Ame.

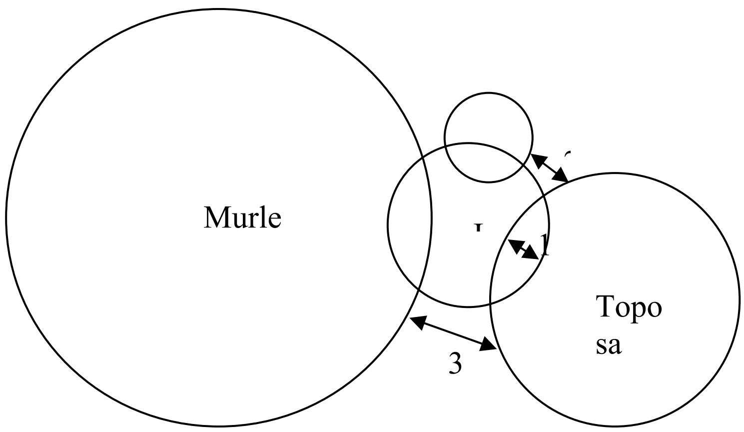
**Figure 1: The four clans of the Jie**




Notes for Figure 1

The four clans of the Jie as drawn by Jie and Murle animal health workers. Note that Nyiresa is the largest clan followed by Tarakabon, Nyamakadol and Nyakurunu. The extent of overlap indicates the extent of contact between groups. The Nyakurunu, the smallest clan, interact very closely with the Nyiresa. The Tarakabon and Nyamakadol interact, especially along the Kengen.

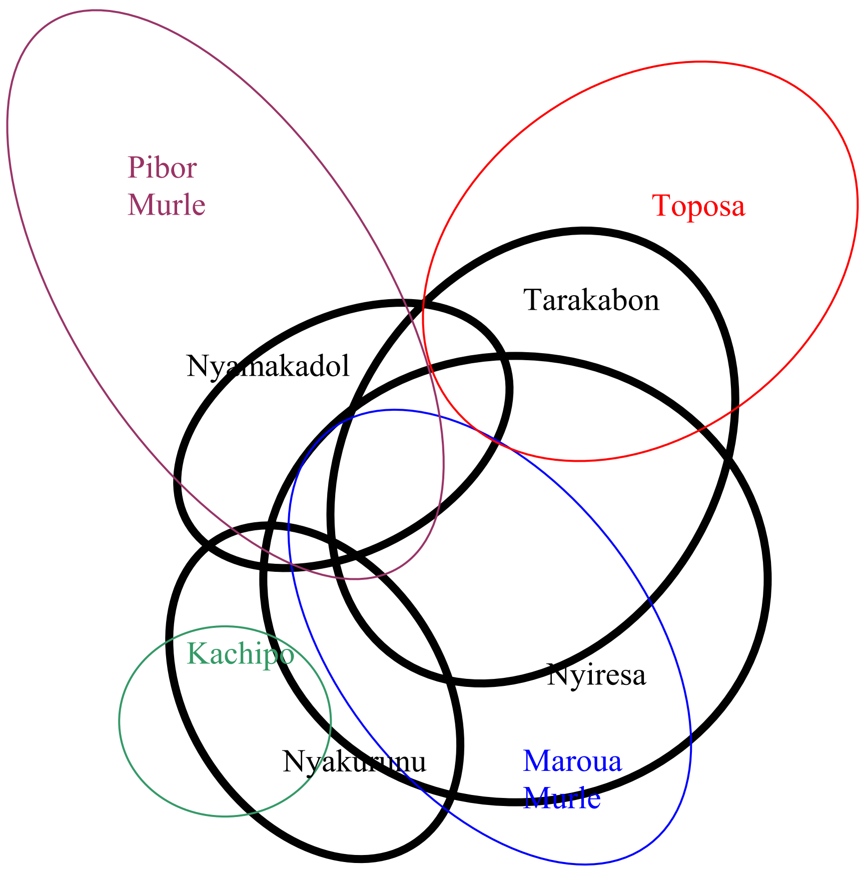
**Figure 2: The relationship between the Jie and surrounding communities**




Notes for Figure 2

The figure represents the interactions between the Jie and the Murle, Toposa and Kachipo as conceived by the mainly Jie respondents in the exercise. Overlap of the circles indicates contact including herding, exchange/loan of livestock and payment of dowry. The arrows indicate raiding iterations prioritised by the size of the problem. Note that the diagram indicates that the Jie are a key link between the three other groups who have limited direct contact with each other.

**Figure 3: The relationship between the Jie clans and surrounding communities**



Notes for Figure 3

The four Jie clans are shown as heavy circles or ellipses. The surrounding tribes are shown as light, coloured circles or ellipses. Note that the sizes of the shapes representing the Jie clans are representative of the relative size of the groups. The surrounding communities Kachipo, Pibor Murle, Marowa Murle and Massingo Toposa were added in after the drawing of the Jie clans. These shapes were sized so as to be able to illustrate the degree of interaction with the Jie groups and not representative of the relative size of the community. The Pibor Murle and Toposa are actually a very large group relative to the Maroua Murle.

# Part Two: Studies in Mwanza, Tanzania

## 2.1 Summary of initial mission

The first mission to Mwanza was a preliminary mission of 4 days duration. Initial discussion with the staff of the Mwanza VIC indicated that CBPP had been present for some time Tarime District to the north of Mwanza. It appears to have entered these areas in the mid-1990s (1994-95) when CBPP re-entered Tanzania from Kenya. Over the past two-three years, sporadic reports had been received from the Shinyanga region from the more pastoral portions of the Wasukuma community. Up to the time of the mission, reports had not been received from Kwimba District. A report had been received for the first time from the Tatuga areas of Meatu District just prior to the mission.

The Animal Health Services Project (AHSP) operating from the VIC Mwanza established sentinel herds and a serum bank for areas of project activity. These mainly cover Kwimba District but include some herds in Shinyanga District. More recently, the Mwanza VIC had just completed a randomised serum collection exercise for PACE where herds were recorded and animals marked. CAPE provided serum tubes to the VIC in order that the samples could be split and aliquots maintained at the lab for possible CBPP testing. Approximately 5000 sera were collected from Serengeti and Tarime Districts in Mara Region and Meatu District in Shinyanga Region.

### 2.1.1 Sukuma near Mwanza

The interviews in Mwanza began with the Wasukuma in a village (Ibindo, Kwimba) where the AHSP had trained Community Animal Health Workers. This area is very agricultural, but the community still keeps large cattle herds and livestock ownership is an important component of the culture and food security in the event of crop failure. Large cattle dowries are a prerequisite for marriage. The interviews were very successful and the team was impressed with the quality of the CAHW. Existing veterinary knowledge was strong, and it was clear that CBPP was not present in the vicinity.

### 2.1.2 Tatuga of Mwabagimu village

As the mission objective was the study of CBPP under pastoral conditions, it was agreed that the team should try another location. The pastoral Tatuga community of Meatu District was selected due to the recent report from that area and the nature of the husbandry system. The Tatuga are a small community related to the Masai. After travel time, one full day could be spent with the Tatuga.

The results were interesting and highlighted the importance of participatory epidemiology. The Tatuga have very well developed existing veterinary knowledge and retained a subtle ability to observe and describe animal health problems. They reported that *shidugwega*

(CBPP) began in April of 1998 in the grazing areas in a few herds.[1] Each year it spreads to more herds. As it enters a herd, it results in heavy mortality, up to 70 to 75%. In subsequent years, mortality in the herd is sporadic. Representative cases were presented and examined at the manyatta of Mr. Mwandu.

A proportional piling exercise was completed to better understand the spread of disease. Respondents were given one hundred beans and asked to illustrate the spread within the herd by dividing the beans into piles. The herders preferred that each bean represent a herd and they divided the beans to show how many herds were affected in each of the first three years of the introduction.

**Table 9: Proportional piling exercise on the spread of CBPP in Tatuga herds**

| | First Year | Second Year | Third Year | Not-Affected |
|---|---|---|---|---|
| Herds | 11 | 33 | 35 | 21 |

Notes for Table 9

The results are indicative of progressive spread within the community. Note that the exercise indicates that 79% of herds were infected by the end of three years. Respondent -Kinyangira.

The piling exercise indicated that the introduction of CBPP into the community was well established. The quality of information suggested that more detailed data collection and replication could provide useful information on herd level transmission using an historical approach.

Although the first report to the veterinary services was received weeks before the mission, yet the disease had already spread throughout the community and was in fact endemic. Livestock owner information provided a detailed picture of the introduction and subsequent spread. If participatory approaches had been part of the standard surveillance system, this situation could have been detected much earlier and appropriate interventions undertaken. As a result of the mission, the local authorities took prompt action by collecting serum from two Tatuga herds and initiating a vaccination programme in the community.

Livestock owner intelligence regarding SE syndromes was also collected. They mentioned two diseases. The first disease, *udamenge da duguoyi*, occurred in their great grandfathers' time. A 94-year-old elder had heard of the disease from his father, but not seen it. It was described as the worst livestock disease ever. The second was *ushida* and was described as diarrhoea. The community stated that the British had constructed crushes and eliminated *ushida*. They had not experienced any problems in recent times.

Another interesting observation was that by chance no herds in the Tatuga community were selected as part of the PACE random sample. This illustrates one of the problems of centrally designed, random samples in structured livestock populations. Stratification could overcome the problem, but this requires good local knowledge. This knowledge of community structure is best obtained through PE methods. This is not a criticism of the Tanzanian programme, as they are correctly implementing PACE and OIE recommendations. The issue of contact structure and random vs. purposive sampling should be considered in regional recommendations and international guidelines.

[1] In the second mission, further interviews revealed an earlier *shidugwega* epidemic that respondents placed in about 1993. This corresponds fairly well with the well recognized epidemic re-introduction of CBPP to Tanzania.

Brief interviews were also completed in the market at Mwanhusi town with Wasukuma farmers. Although not enough time was spent to draw firm conclusions, the interviews suggested that CBPP had not spread from the Tatuga herds to the Wasukuma areas despite the geographic proximity of the two groups.[2]

Given the available intelligence on the CBPP situation, it would be most appropriate for the second mission to focus on the Tatuga community and in one of the CBPP affected areas of Tarime or Mara Districts where CBPP is known to be endemic. Detailed participatory data on the evolution of the CBPP introduction can reveal substantial information about CBPP dynamics both in regards to new introductions and endemic disease. The experience of the local communities has been remarkable in terms of the severity of the initial introduction, thus interest levels should be high.

A serological evaluation of selected communities from the PACE sample would also be worthwhile as the basis for a prevalence estimate. Selected herds could be identified for re-bleeding to gather information on within herd incidence. A memorandum of understanding should be prepared with PACE Tanzania that outlines the work to be completed, respective responsibilities and source of funding.

## 2.2 The Tatuga of Mwabagimu village

The second mission began by focusing on the Tatuga of Mwabagimu Village, Meatu District. The community consists of 300 to 350 households and is estimated to hold a cattle population of 20,000 head. The area is a semi-arid plain to the West of Lake Eyasi with an escarpment along its northern border (Figures 9 and 10). During the dry season, the cattle are taken up the escarpment to grazing areas along branches of the Sayu River near Mwasa Game Reserve. The cattle are in these areas from June/July until November, after the first rain.

A partial lexicon of Tatuga disease terminology was constructed on the first day (Table 10). *Shidugwega* was the first disease mentioned and the most important in a ranking exercise. In every interview except one, *shidugwega* was the first disease mentioned and more than one respondent did not choose to discuss any other diseases.

### *2.2.1 Shidugwega*: The Tatuga perspective on CBPP

*Shidugwega* was described as a disease that presented with standing hair coat (fever), loss of appetite and coughing. The animal in the acute phase was described as standing with the front legs abducted, head extended and nostrils flaring. When asked if there was anything unusual about the neck, herders pantomimed a jugular pulse. If the animal died acutely the lungs were stuck to the ribs. In chronic, wasted cases, the lungs smelled rotten.

The respondents reported that *shidugwega* first appeared about ten years previously as a catastrophic outbreak of disease. The year was named as *gweida asela dugwa* or the year of massive cattle death (Table 11). Thereafter, *shidugwaga* subsided. Some elders report that the disease was not present for the subsequent five years; others state that it was present at a very low level. It was reported to be causing heavy mortality in at least one neighbouring community in Shinanga District (the Sukuma of Magarata) and in Monkara in Meatu District for the two years following *gweida asela dugwa*. *Shidugwega* was reported to have resurged

[2] Interviews during the second mission with Tatuga and Sukuma respondents indicated that the disease was well established in Sukuma areas around Bukundi and neighboring villages in Shinyanga as far back as the mid-1990s. Livestock officers from Mwanhusi, the Meatu District capital, who were attending the Makundi market, stated the disease was suspected around Mwanhusi as a result of investigations stimulated by an earlier mission.

in Mwabagimu 4 years previous to the team's visit in *gweida mapalage* (also called *gweida mafuriko* or the year of floods due to El Nino) and to have been a major concern during the subsequent years (*gweida sabasabira, gweida ishi* and the current year). The Tatuga consider the year to start from the rains in mid-October (Table 12) and only name years when unfortunate events occur.

The disease was reported to start from the grazing areas and that the cattle brought it down to the manyattas each year. The elders reported that an animal could get *shidugwega* more than once. They stated that the disease lasted a few days up to a month. In rare cases it might last three months. Elders were asked to describe specific cases of recurring disease by naming cattle and then describing their clinical history. These are summarized in Text Box 1.

**Box 1: Clinical histories**

**Chronic Cases**

*Buashi*: Fell acutely ill in January 2002. She was treated, but up to this moment she is not in good condition. She is weak, has a rasping coughing. She breaths normally when at rest, but her breathing becomes laboured when she exercises. Ill for 8 months to date.

*Mera*: Fell acutely ill March 2002. Her present condition is like *Buashi*. Ill for 6 months to date.

*Awishi*: Fell ill in 1998. Treated and recovered but fell ill again after 6 months. Thereafter she is getting the disease every year and is treated.

*Bashit*: Developed *shidugwega* in March/April of 2001. She was sick for 5 days, but treated and grazed normally for one month. Since has had a wasted appearance and a cough up until the present. This is a duration of 18 months to present.

*Mwega*: He developed *shidugwega* in March/April of 2001. He was sick continuously for one month. He showed signs of recovery for about five days and then relapsed. This has been his pattern ever since. He was last treated one month ago.

*Umu*: Fell acutely ill 4-5 years ago at the start of *domilda* (the onset of the rains in late October). He was treated and recovered but fell ill in the dry season 18 months later. He was treated and is in good condition now.

*Juruguda*: He fell sick in the dry season 4-5 years ago, was treated and recovered. He fell sick again at the beginning of the rains in the subsequent year. This is 15 to 18 months after the first onset.

*Muyamba*: First developed *shidugwega* three years ago. She recovered after treatment but fell sick again 12 months later.

*Magau*: First experienced *shidugwega* four years ago. She has been sick many times since.

**Acute Cases:**

*Sanagu*: Fell acutely ill in January 2002 and died after 10 days despite treatment.

*Buashi*: Died per-acutely in January 2002 after 12 hours. Lungs were adhered to the rib cage.

*Mera*: Fell ill in mid-*mehuir* (February) 2002. He was treated and recovered fully.

*Delani*: Fell ill in mid-*mehuir* (February) 2002. Treated but died after 5 days.

The descriptions were more consistent with clinical recurrence of chronic disease than reinfection. The cases described recurred from a few months up to 18 months after the initial onset. In two cases, chronic recurrent disease stretching over many years was described. Almost all cases first became apparent during the rains.

On the last day, after suggesting that recurring cases of *shidugwega* were really never cured in the first place, an elder provided the following comprehensive explanation:

> … The disease begins when the grass is short. An animal that was sick the year before can get sick again now…. There is nothing to graze between the first rain and the growth of the short grass. The rains come first in the grazing area and then down here at the manyattas. The cows stay in the grazing area until the short grass is at the manyattas. The period between the rains and the short grass and change in pasture from the grazing areas to the manyattas are difficult times for the cows. The disease begins at the time of the short grass in the grazing areas and then the cows come down to the manyattas with the disease. It continues throughout the rains. Both recurrent cases and new cases occur at the time of the short grass...
>
> Tatuga elder (paraphrased)

This suggests that the disease has a seasonal pattern and that the perspective of the Tatuga on recurrent cases is different from that of the Jie in southern Sudan. The increased contact rates in the grazing area and stress of the onset of the rains can account for this seasonality.

**Table 10: Disease Terminology of the Tatuga**

| Tatuga Name | Translation | Western Term | Description |
|---|---|---|---|
| *Gariti* | tsetse fly | tsetse and trpanosomiasis | coughing, standing hair, chronic weight loss, death if not treated |
| *giyura shidugwega* | disease of lungs | CBPP | standing, hair stands on end, coughing (*washenda*), grunting, drooping ears, walks with difficulty, lachrymation, death lungs solid, dark and adhered to chest wall |
| *Idangweshika* | disease of lymph nodes | | swollen lymph nodes |
| *Serefiti* | | foot and mouth disease | sores of feet and mouth, if occurs in dry season cattle can starve |
| *Uraguida (urafugenda)* | disease of liver (disease of blood) | babesiosis and possible others | acute enlargement of liver and gallbladder, bloody urine |
| *urameng'ira* | | blackleg | swelling of the muscles of a limb, crepitation, bloat, frequent death |
| *Uramguri* | | 3-day sickness | lie down, cannot walk for two or three days, occurs at end of rains (March-April) |
| *Uramuuguka* | | hemorrhagic septicaemia | swelling of throat in calves and yearlings, rapid death |
| *Ushida* | | rinderpest | diarrhoea, lachrymation and death, not seen in 40-45 years |

### 2.2.2 The Tatuga method of treatment and possible implications

The Tatuga treat all cases of *shidugwega* with tetracyclines (10%). The typical approach is to give two injections of 10cc per day, once in the morning and once in the evening. They normally inject through the chest wall into the pleural cavity. Reports of correct intra-muscular application were occasionally received. Thus, they administer something approaching a correct dose by an incorrect route. Treatment is continued for 2 to 5 days depending on the clinical response. Treatment is reapplied if the animal relapses.

Estimates of mortality in treated animals ranged between 20 and 80%. When asked for estimates of mortality in un-treated cases, respondents stated that they thought it would be 100%, but admitted that they never dared try it.

The author is not aware of the efficacy of tetracycline administered through the chest wall, but one might assume that it is somewhat effective. It is probably more effective than the Jie method of injecting suspensions of one or a few tetracycline capsules. In addition to saving lives, the form of treatment may pre-empt death or the development of solid immunity and predispose a percentage of recovered animals to clinical relapse. Alternatively, treatment may provide a respite in what would otherwise be a chronic clinical case. These questions will be discussed later in the final section of the report that reviews the literature and discusses modelling issues relative to field observations.

**Table 11: Tatuga annual calendar**

| Year | Name | Translation |
|---|---|---|
| 1992-93 | *gweida ashela dugwa* | year of massive cattle death (*ushidugwega* introduced) |
| 1993-1998 | not named | |
| 1998-99 | *gweida mapalage*<br><br>*gweida mafuniko* | year of dried potatoes (hunger during dry season)<br>year of floods (El Nino during the rainy season) |
| 1999-00 | *gweida sabasabira* | year of army worm |
| 2000-01 | *gweida ishi* | year of no-rain |
| 2001-02 | not yet named | current year ending in mid-October |

<u>Notes for Table 11</u>

After repeated probing in numerous interviews it was apparent that the years between *gweida ashela dugwa* and *gweida mapalage* were not named. Thus, it was not possible to count back to establish the exact year of *gweida ashela dugwa*. The Tatuga state that these years were not named since 'nothing bad happened.'

**Table 12: Tatuga seasonal calendar**

| Tatuga Season | Months | Tatuga Description |
|---|---|---|
| *Domilda* | October 15th - December | 'rains' |
| *Mwira* | January – March | 'heavy rains' |
| *mehuir* | April – June | 'between rains and dry season, crops harvested at end' |
| *Geida* | July - October 15th | 'dry season' |

**Table 13: Age classes of Tatuga cattle**

| Age | Class | Description |
|---|---|---|
| 0-1 year | *meida, mhuga (pl.)* | Calves |
| 1-2 years | *walanil* | Weaners |
| 2-4 years | *Hawen* | females (heifers) |
| | *Heida* | castrated bulls |
| | *kaheinra* | intact bulls |
| Adult | *juruguda* | adult bulls |
| | *nyabuldahau* | adult cows |

## 2.3 The Kurya of Gibaso Village, Tarime

### 2.3.1 Introduction

Gibaso village lies on the west bank of the Mara River at the northwest edge of Serengeti National Park near the border with Kenya at an altitude of 1200 meters. An escarpment rises to the West that runs north into Kenya. Masai Mara lies to the north across the border in Kenya. It is predominantly a sedentary livestock keeping community with about 4,600 cattle divided between 300 households. Herd sizes range between less than ten to 100. They graze their cattle in household herds more or less within the confines of the village boundaries. The cattle have contact with herds from the neighbouring villages at shared watering points on the Goniche and Mara Rivers. Genkuru and Kitawasa, which are at the top of the escarpment, have smaller cattle populations. Morito is also at the base of the escarpment but to the south. Genkuru has a cattle population of 1400 whereas Murito is estimated to hold 4000 head. The cattle also have seasonal contact with wildlife that visit watering points in the village during the period July to November.

The area was regarded as relatively insecure until the mid-1980s due to cattle raiding and inter-clan conflict. Community members report that their first real contact with livestock officers was in 1986.

The Kurya provided descriptions of numerous livestock diseases. Prominent among these was *ekehaha* (CBPP), *mhangarima* (cerebral ECF), other tick borne disease and various presentations of trypanosomiasis (Table 14). Some diseases were described symptomatically without a name in Kurya. Swahili names or corrupted Swahili names were also sometimes used.

### 2.3.2 The history and patterns of Ekehaha

The Kurya provided very clear and specific descriptions of CBPP going back to 1986. Further, many elders maintained that the disease has been present continuously since their childhood in the 1950s and described events in 1956, 1958, the 1960s and early 1980s. As a result, the Kurya raised doubts as to whether or not CBPP was ever fully eradicated from Tanzania. It was concluded that the evidence at least supported a re-introduction well before 1992. A sizeable number of respondents described major CBPP events in the period 1985-87. This included livestock owners, paravets and livestock field officers. Several reports of a major event in Gibaso clinically indistinguishable from CBPP were received regarding 1986. Affected herds were investigated and field staff reported CBPP. Follow-up did not take place for four months and by that time the affected herds had experienced raids and were transported south to Serengeti District (Mara Region). It was further reported that the disease subsequently spread to Bunda (Mara Region) and Bariadi (Shinyanga Region). One informant stated that this caused the disease to spread to Bunda and Bariadi. The isolation of the community may in part account for this discrepancy with official history.

Of all the interviews, only two respondents identified a seasonal pattern in CBPP outbreaks. Others described periodic flare-ups without any particular season. The predominant description was that the disease shifted from herd to herd and that *ekehaha* was almost always present in the immediate neighbourhood. Although smaller herds of ten cattle could go up to three years without a case, respondents reported that they never went more than three months without a clinical case in the neighbourhood. Moving from sub-village to sub-village, the team did not detect any waves of disease that covered the entire village.

On the other hand, seasonality was reported for vector borne diseases and linked to wildlife movements.

This suggested a more or less stable endemic pattern of CBPP transmission without any apparent periodicity or seasonality on a larger scale. The constancy of grazing patterns and rather restricted contact with outside cattle populations could explain this apparent lack of periodicity.

**Table 14: Kurya disease terminology**

| Kurya Term | English Term | Description |
|---|---|---|
| *Amageka* | | circling, continues grazing, occasionally fatal, responds to local treatment or tetracycline. |
| *Amakababe* | East Coast fever | swollen lymph nodes in calves, treated with tetracycline and burning of nodes. Kurya also say *endigana kali* from the Swahili name 'ndigana kali'. |
| *Cherahasa manyinga* | bloody diarrhoea | This common symptomatic term is used as the name of a disease and apparently can refer to either trypanosomiasis or terminal ECF. |
| *Chirsinyora Manyinga* | babesiosis | literarily 'bloody urine' caused by ticks. |
| *Ekehaha* | CBPP | standing hair, coughing, anorexia, dyspnoea, lungs enlarged with lumps inside and adhered to chest wall. |
| *Iriboko* | blackleg | acute swelling of one limb, crepitation, carcass unfit for consumption. |
| *Mhangarimu* | cerebral East Coast fever | salivation, nasal discharge, blindness, whitening of the eye, head pressing, collapse with paddling, always fatal. |
| *Nyamachoke* | chronic FMD | long hair, seeks shade, panting (Figure 12). |
| *no specific name* | trypanosomiasis | intermittent fever described as change of colour or standing hair coat (Figure 13). |
| *Sanabi* | foot and mouth disease | contagious lesions of feet and mouth. |
| *Rikengeti* | acute fever | Shivering and death. Skin hot to touch. Also called 'malaria'. Some claim cases can be treated with tobacco and include lameness. Term may cover acute trypanosomiasis and three day sickness. |
| *Ukibarabara Giruhuma* | anaplasmosis | standing hair, weight loss, contents of omasum dry. Kurya also say *endigana baridi*, probably from the Swahili 'ndigana baridi' |
| *Umchohe* | trypanosomiasis | chronic weight loss despite grazing caused by 'ndorobo', also called 'nagana' |

### 2.3.3 Vaccination

Vaccination with T1/44 CBPP vaccine produced in Botswana took place in March, 2002. Most respondents reported that reactions and mortality as a concern and about one-third of the respondents gave specific evidence. The team observed one animal with a draining tract on the shoulder in October. The statistics provided by three herders are summarized in Table 15. The paravet summarized the situation by saying '*If I had assisted at the vaccination, I would probably have to move.*' This statement will need to be taken into account in any future community-based CBPP control strategies.

**Table 15: Prevalence of vaccination reactions in three herds**

| Herd | Herd Size | Morbidity | Mortality |
|---|---|---|---|
| 1 | 20 | 10 | 2 |
| 2 | 65 | 11 | 6 |
| 3 | 20 | 8 | 2 |
| Total | 105 | 29 (27.6%) | 10 (9.5 %) |

Reports on the impact of vaccination on the incidence of disease varied from no effect to a moderate suppression of clinical cases. One respondent stated that the effect of vaccination lasted 4 to 6 months. The experience of the farmers will preclude high vaccine uptake in the next round of vaccination and is definitely not compatible with effective control in the absence of draconian measures.

The District veterinarian stated that reactions were confined to the villages surrounding the Gibaso area. He further indicated that the same batch of vaccine was used throughout the district and that no one as yet had provided an adequate explanation for the problem. One explanation that is sometimes advanced for reactions is inadequate hygiene. It has been recommended that needles be frequently changed in the course of vaccination sessions and many field veterinarians attest to the efficacy of this safeguard in preventing reactions.

Sporadic vaccination is of limited value against CBPP. However, the cost and logistical demands of CBPP vaccination make the sustainability of a national biannual programme very doubtful. It would be much more prudent, and probably assist farmers more, to provide reliable access to CBPP vaccine on a privatised, elective basis in combination with a well developed extension package on how best to control CBPP at the herd level.

### 2.3.4 Duration, recurrence and methods of treatment

The Kurya maintained that CBPP could take a chronic course or could recur in apparently recovered animals for a period of up to one year after the initial episode. The relative frequency of acute vs. chronic cases and the length of chronic infections were probed verbally and in proportional piling exercises. To a lesser extent, the relative frequency of recurrence and the interval between apparent recovery and recurrence were also explored.

The distinction between chronic and recurrent clinical cases is not absolute. Selected animals 'that never did well again' could be described as falling into either category. What was clear was that there were animals that demonstrated full clinical recoveries and then fell ill again, usually within a period of months.

As with the Tatuga, virtually all clinical cases were treated. Treatment consisted of oxytetracycline administered intra-muscularly in appropriate doses. The course of treatment was based on clinical response. If the animal recovered after one, two or three injections, treatment was discontinued. If the case dragged on, treatment was usually continued sporadically on a sub-optimal schedule.

It was difficult, if not impossible to standardize the piling exercises on acute vs. chronic, recurrent cases and length of the clinical course. This was because each farmer had a slightly different interpretation of what constituted a chronic case vs. a relapse and the period of time over which the disease could persist or recur. In the spirit of PRA, it was deemed more productive to let the farmer have some control over the structuring of the piling exercise so that he could best express the information he wished to communicate. The results of the aggregate of the proportional piling exercises regarding the amount of acute vs. chronic disease and respective mortality rates are summarized in Table 16.

**Table 16: Summarized Results of Proportional Piling on Clinical Course**

| Course | Percent of Cases | Percent Recovery | Percent Death |
|---|---|---|---|
| Acute | 78.3 | 47.2 | 52.8 |
| Chronic | 28.4 | 55.6 | 44.4 |
| Overall | | 49.0 | 51.0 |

<u>Notes for Table 16</u>

Farmers considered acute cases as those that either died or fully recovered within 3 to 4 weeks. Within the acute group, some farmers clarified in probing questions that recovered acute case code could recur within a period of one year.

One farmer was asked to indicate what fraction of acute and chronic cases recurred after apparent recovery and then to break recurring cases down according to the length of time before recurrence. The piling indicated that 23.5% of recovered acute cases recurred and that 30.2% of chronic cases recurred (Table 17). Farmers indicated that chronic cases that persisted longer than 3 to 6 months seldom recovered. The window for recurrence was ranged between 3 months and 12 months depending on the respondent.

**Table 17: Example of Results for Elapsed Time until Recurrence**

| **Acute** | | | | **Chronic** | | | |
|---|---|---|---|---|---|---|---|
| Total Score | <1 month | <2 months | > 2 months | Total Score | <1 month | <2 months | > 2 months |
| 8 | 4 | 2 | 2 | 13 | 6 | 3 | 4 |

<u>Notes for Table 17</u>

The breakdown of the bean score for recurring cases in both the chronic and acute categories is presented by length of time to recurrence. The respondent used a course of more than 2.5 weeks as the criteria for assigning cases to the acute vs. chronic category. This farmer stated that chronic cases could go for up to 4 to 5 months and still recover.

In general, the breakdown of scores into acute vs. chronic cases and length of clinical course showed limited variation whereas indications of mortality were highly variable. Herd sizes where small and the variability in reported mortality may have reflected actual individual experience. It was clear that mortality was appreciable.

## Part Three: Modelling CBPP, Existing Veterinary Knowledge and the Literature

### 3.1 Southern Sudan

In regards to future modelling work the study in southern Sudan has provided key information. Clearly the herders have indicated that CBPP is stably endemic with a seasonal dimension to the severity of clinical cases. They have demonstrated that they detect a range of clinical severity and time courses. The livestock owners have noted that the primary source of infection is contact with cattle in their own herds and surrounding communities. They have also described significant levels of mortality on par with other disease concerns such as trypanosomiasis and fascioliasis.

Given that the herders described a subtle range of presentations and reported that *louko* was always present in their herds, it was not considered appropriate to try to estimate the incubation period of CBPP from PE data. For modelling purposes, the study will utilize available estimates in the literature.

The incubation period for CBPP has been described to range between 20 and 123 days. The incubation period for 46% of cases fell between 20 and 30 days, 23% between 31 and 40 days, 11% between 41 and 60 days and more than two months for the rest (Provost et al., 1987). The authors provide neither a methodology for this estimate nor a reference to original research. Karst reported an incubation period of 29 to 207 days (1970). It would appear that these periods reflect the time of exposure in an outbreak situation until the time of onset of clinical signs. The more correct definition of incubation period is from the time of infection until the onset of clinical signs.

Determining the point of infection is CBPP is difficult. Apparently superficial infection of the respiratory tract in control animals has been documented as part of in-contact challenge vaccine trials (Gilbert et al., 1970). A review of four studies that utilized various standardized and documented methods of in-contact challenge found that all except two control animals that developed invasive infection did so within 4 and 10 weeks (Davies et al., 1968; Gilbert et al., 1970; Windsor et al., 1972 and Masiga and Read, 1972).

Historically, Turner (1954) describes the importance of recovered, apparently healthy animals in the epidemiology of CBPP. This author notes that sequestra can persist for long periods and that viable organisms can be obtained from such lesions for up to two-three years. As with most papers in this vein, the author fails to provide any evidence that sequestra actually act as a source of transmission.

Turner (1954) describes the detailed history of two outbreaks and notes that 25% of the animals failed to become infected despite long periods of contact. This suggests that the end point of the outbreak had been reached and $R_0$ can be calculated. The data is consistent with a herd level $R_0$ of 4.

Windsor and Masiga (1977) have published the results of extensive experiments designed to test the role of sequestra and the reactivation of recovered cases in the epidemiology of CBPP. They attempted to transmit CBPP from recovered animals to susceptibles by using various stresses (exercise, starvation and water deprivation), large doses of corticosteriods or splenectomy to reactivate cases in the presence of susceptible contacts. They were uniformly unsuccessful and concluded that sequestra do not breakdown frequently.

Windsor and Masiga also attempted to reinfect recovered animals up to 30 months after a primary episode of disease by contact or endobronchial intubation. Cases did not result. The authors concluded that recurrent infection was not a common process.

> *'All this suggests that once an animal has experienced infection with M mycoides and recovered, it is less potential danger to clean animals than has been thought. … this study suggests that carrier animals play only an occasional role in the epidemiology of CBPP…'*

Masiga and Windsor, 1977 pg. 229

In the Boma study, the herders clearly indicated that the disease did not recur in recovered animals. Livestock owner information suggests that chronically affected animals are the source of disease persistence rather than reactivation of recovered cases. Thus, existing veterinary knowledge in southern Sudan is in close agreement with the findings of Windsor and Masiga. The results also suggest that if the goal is suppression of disease and not eradication, chronic sequestra are not an appreciable concern.

Mefit-Babtie (1983) reported the results of a small CFT serosurvey including 123 Dinka, 24 Nuer and 52 Shilluk cattle and found 8, 4 and 2% positive, respectively. Further, of 59 Dinka cattle reported to have a history of respiratory disease, 16 (27%) were positive by CFT. Of 15 Dinka animals that had no history of respiratory, 0 (0%) were positive. Of the 59 animals reported to have had respiratory disease (*abut pio*), 21 cases occurred in the year of testing, 32 one-year previously and 6 two-years previous. Of these 8 (38%), 7(22%) and 1(16%) were positive, respectively. Given the short duration of CFT antibodies, these results suggest the predictive value positive of a Dinka diagnosis of recent CBPP approaches 38% and a predictive value negative of 100%. The sample size is small, but the result suggests a remarkable diagnostic ability given the insidious nature of CBPP. It is also an objective result that contradicts a frequent, subjective generalization to the effect that herders cannot adequately diagnose disease.

Mefit-Babtie (1983) also describes a small outbreak of CBPP in a herd of local cattle assembled for production studies and monitored with the CFT. He notes that 2 strongly seropositive cows resulted in 9 apparently secondary cases in 30 in-contact calves tested by CFT roughly 50 days after introduction of the cows. This would be analogous to an $R_0$ of 4.5. The symptoms ranged from unapparent disease to death in two cases.

Zessin et al. completed an analysis of surveillance data on CBPP among the Dinka and Fallata communities of Bahr el Ghazal (1985). These authors found a seroprevalence of 8.1 and 9.2% in Dinka and Fallata cattle, respectively. At the herd level, the prevalences were 48 and 20% positive, respectively. The prevalence of CFT antibody was significantly higher among the age group of 3 months to 3 years. They reported that the pattern of overt disease was sporadic and not epidemic. It was noted that the Dinka were capable of recognizing both mild and severe clinical cases, however the authors concluded that many mild or unapparent cases must pass unnoticed or are ignored. They did not find an association between crude mortality rates and CBPP prevalence rates and found that CBPP was not a major cause of mortality. Seroprevalence rates were lower in slaughterhouse samples than in the general population indicating that livestock owners did not selectively slaughter infected animals.

In Kongor, McDermott et al. (1987) found a CBPP CFT seroprevalence of 8.1% in an age-stratified sample of Dinka cattle collected in January 1984. The highest prevalence was found in an age category of 2 to 4 years and this was noted to be a slightly older age group than found by Zessin et al. Contagious bovine pleuropneumonia was described as an endemic disease that manifested itself primarily as 'non-specific pneumonic symptoms with low grade fevers, only occasional coughing and low case-fatality rates.' The authors noted a statistically significant association between herders' diagnosis and laboratory diagnosis in younger age groups. This suggests that Dinka herders were either fairly good at diagnosing mild disease or the disease was more severe than recorded.

Masiga and Windsor (1978) showed that cattle under three years of age were significantly more susceptible to challenge with virulent CBPP when death was used as the criteria for severity of disease. Nine of 31 animals between 1 and 3 years of age died whereas none of 16 animals over three years of age died due to an identical treatment.

The information provided by the Jie, Murle and Dinka in the Boma area agreed with many points of the three papers (Mefit-Babie, 1983; Zessin et al., 1985 and McDermott et al., 1987) describing the epidemiology of CBPP in the Dinka communities of Bahr el Ghazal and Kongor. However, the communities of Boma were clear that CBPP was a major source of mortality. The severity of cases presented to the author of this report would lead one to believe that CBPP is an important source of mortality.

Zessin et al. (1985) noted '*because* the Dinka husbandry system makes animals rotate and circulate extensively, such an endemic state with 'disease stability' is readily reached.' Our informants indicated that CBPP was endemic with peaks of mortality during periods of stress such as the onset of the rains and the height of the dry season. These times are associated with or come directly after periods of elevated cattle contact in the dry season grazing areas. As noted in the section on Jie community structure, the traditional exchange of livestock would indeed appear to facilitate the establishment and maintenance of endemic stability.

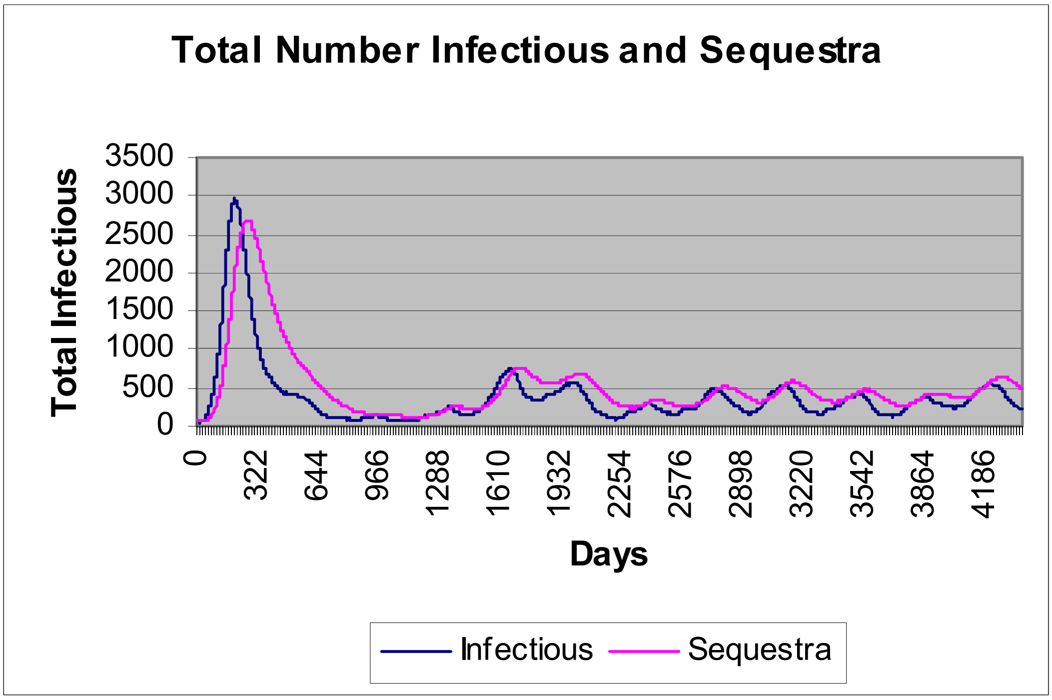
Zessin et al. (1985) suggested that a targeted approach to CBPP control would be warranted based on a disease intelligence system that involved the livestock owners. Only vaccination, and not treatment, was considered as an intervention. We would like to suggest that treatment of severely affected animals with ring vaccination of contacts be considered as a targeted intervention. Ultimately, the herders, through their trained representatives, should be empowered to undertake such targeted interventions.

## 3.2 The Tatuga

Preliminary modelling of the pattern of disease described by the Tatuga was completed. When the population estimate of 20,000 fully susceptible head was fit into the core CBPP model using preliminary parameter estimates (Mariner, 2002), introduction of 60 infected cattle, and a seasonality weighting of 50%, representative patterns very similar to that described by the Tatuga resulted (Figure 4). Note the initial catastrophic epidemic followed by an eclipse of 4 to 5 years. The endemic pattern then settles down into annual cycles of peaks and troughs. This partially validates the model and suggests that the pattern described by the Tatuga is epidemiologically plausible to the point of mathematical consistency.

It should also be noted that the recrudescence of CBPP coincided with an El Nino event and this may have reinforced (or forced) the epidemiological pattern.

**Figure 4: Preliminary simulation of CBPP dynamics in the Tatuga community of Mwabagimu**




### 3.3 The Kurya

Unlike in the other groups, the pattern of disease in the Gibaso Kurya cattle population was not seasonal and as one moved from herd to herd, no net annual trend could be identified either. Although heavily reliant on cattle, the Gibaso Kurya do not practice transhumance and there is no major change in cattle contact rates throughout the year. If the Gibaso Kurya are contrasted with the Tatuga and peoples of Boma, this is a fundamental difference and suggests that herding patterns may be the key factor in establishing the seasonality of disease rather than weather or grazing stress.

In light of this, a weighted trigonometric function has been incorporated in the model that can be used to induce seasonal fluctuations in contact rate or mimic environmental stress. This is a widely accepted technique.

### 3.4 Treatment

With the liberalization and privatisation of the animal health sector, treatment of CBPP cases is the norm. In the de facto absence of implementable national CBPP strategies, CBPP control is a private concern and livestock owners will do their utmost to save their individual animals. Implementation of top-down, restrictive policies on treatment that neglect farmer's perspectives is not realistic.

A review or the literature (Mariner, 2002) shows that most field and laboratory studies of recovered and chronic un-treated cases find the preponderance of animals who survive the acute phase (or even sub-clinical infections) have sequestra. Studies have shown that sequestra in recovered animals that did not receive treatment are difficult to re-activate

(Windsor and Masiga, 1977). To our knowledge, there is no formal data on the formation or re-activation of sequestra in treated animals.

Whereas the Jie and Boma Dinka described more-or-less chronic disease in a fraction of cases but that an animal could *only get CBPP once,* the Tatuga and Kurya perspective was that an animal could get the disease more than once within a limited time frame. The author suspects that the difference in these perspectives may be due to the wider availability and use of antibiotics in the Tatuga and Kurya areas. This suggests that in addition to providing cures, treatment can induce temporary clinical improvements in otherwise chronic cases. It interesting to note that a Bor Dinka CAHW interviewed in 2001 stated that animals responded well to treatment, but that cases could recur (Mariner, 2001). This suggests that the Dinka in Bor who have access to antibiotics have a view similar to the Tatuga and Kurya.

For modelling purposes, we would like to suggest the assumption that treatment does not favour the formation of sequestra or chronic carriers. Treatment favours survival and the formation of sequestra is the normal course of the disease in survivors. In this sense, treatment has the opposite effect of stamping out measures.

The key question for modelling then is *not* does treatment favour the formation of sequestra. The pertinent questions are:

- does treatment reduce the net infectious period and/or
- predispose animals to develop qualitatively different sequestra that are more prone to re-activation?

The alternative hypotheses to be explored in modelling are that treatment:

1. promotes recovery and thereby reduces the net infectious period ($1/\alpha$) without affecting the dynamics of the sequestra in recovered animals,
2. reduces mortality (decreases $\sigma$) without affecting the net infectious period ($1/\alpha$) or the dynamics of the sequestra in recovered animals,
3. promotes recovery and thereby reduces the net infectious period ($1/\alpha$) but increases the likelihood of reactivation of sequestra (increase $\kappa$) in recovered animals or
4. reduces mortality (decreases$\sigma$) without affecting the net infectious period ($1/\alpha$) but increases the likelihood of reactivation of sequestra (increase $\kappa$) in recovered animals.

In options 1 and 2, treatment does not affect the dynamics of sequestra formation, re-activation or resolution. One expects more sequestra because more animals survive, but the nature of the additional sequestra would be no more dangerous than in un-treated survivors.

In option 3 and 4, treatment promotes survival leading to a higher incidence of sequestra in the population and these additional sequestra have a greater propensity to re-activate.

These scenarios can be explored in modelling by increasing the recovery rate ($\alpha$) (hypotheses 1, 3 and 4), increasing the sequestra re-activation rate ($\kappa$) (hypothesis 4) and reducing the specific mortality rate ($\sigma$) (hypotheses 2 and 4).

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