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THE STATUS OF BOVINE TRYPANOSOMIASIS AND SEASONAL VARIATION IN ITS OCCURRENCE IN ZONE 1 (NIGER VALLEY) OF THE REPUBLIC OF MALI

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TABLE OF CONTENTS

		PAGE
ACKNOWLEDGEMENTS		i
CHAPTER I	INTRODUCTION	
CHAPTER II	MATERIALS AND METHODS	1
	A. Description of Zone 1	7
	B. System of Sampling	7
	C. Cattle and Other Livestock Sampled	9
	D. Field Sampling Techniques	10
	1. Collection of Blood Smears	10
	2. Collection of Lymph Smears	10
	E. Laboratory Techniques	11
	1. Staining of Blood Smears	11
	2. Staining of Lymph Node Biopsy Smears	12
	3. Examination of Smears	12
CHAPTER III	RESULTS	14
	A. Relative Diagnostic Values of Three Methods Used	14
	B. Cattle and Other Livestock Sampled	17
	C. Bovine Trypanosomiasis	20
	1. Incidence and Pattern of Distribution	20
	2. Relative Prevalence of Various Trypanosome Species	43
	3. Cattle Morbidity and Mortality Due to Animal Trypanosomiasis	48

TABLE OF CONTENTS
Page two

		PAGE
CHAPTER III	4. Outbreak of Animal Trypanosomiasis at Various Villages	50
	D. Trypanosomiasis in Other Livestock	53
	E. Tick-borne Diseases	55
CHAPTER IV	DISCUSSION	56
	A. Limited Detection Methods	56
	B. Indiscriminate Use of Trypanocides	59
	C. Trypano-tolerant Breeds of Cattle	59
	D. Disease Incidence in the Zone	59
	E. Differences in Susceptibility Among Various Breeds and Age Groups of Cattle	61
	F. Prevalence of Various Trypanosome Species	62
	G. Trypanosomiasis in Other Livestock	65
CHAPTER V	RECOMMENDATIONS	66
	A. Bovine Trypanosomiasis Sample Survey	66
	B. Control by Chemotherapy and Chemoprophylaxis	67
	1. Regimen No. 1	68
	2. Regimen No. 2	69
	C. Establishment of Trypanosomiasis Research and Diagnosis Unit (TRDU)	69
	D. Terms of Reference of TRDU	70
	E. Special and Physical Facilities	71
	F. Staff	72
	G. Human Trypanosomiasis	72
	H. Staff Development and Training	72

TABLE OF CONTENTS
Page three

		PAGE
CHAPTER VI	SUMMARY	74
APPENDIX I	EQUIPMENT, CHEMICALS AND MATERIALS REQUIRED FOR SAMPLE SURVEY	79
APPENDIX II	EQUIPMENT, CHEMICALS AND MATERIALS REQUIRED OF T.R.D.U. (TRYPANOSOMIASIS RESEARCH AND DIAGNOSIS UNIT)	83
APPENDIX III	REFERENCES	87
APPENDIX IV	FIGURES 1 THROUGH 9	

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CHAPTER 1

INTRODUCTION

CHAPTER I
INTRODUCTION

The Republic of Mali, occupying an area of approximately 1,240,000 km^2, consists of four vegetational zones (Coulibaly and Diallo, 1978). They are, from north to south:

1. Sahara
2. Sahel
3. Sudanian savanna
4. Sub-sudanian savanna

The north, and greater part, of the country is Sahara with no grazing available. It merges into the Sahelian zone, which constitutes an important area for Zebu cattle-breeding from June to October. The latter is followed by the Sudanian savanna zone, which has a relatively higher seasonal rainfall and good grazing but which is infested with tsetse flies. The Sudanian savanna leads to the Sub-sudanian savanna zone with a much higher rainfall and abundant grazing compared to the other zones. This vegetational zone, however, is extensively infested with the tsetse fly, with, probably, high disease challenge. Out of an approximate 800,000 km^2 of potential grazing land, an area of about 230,000 km^2 in the southern and western regions of Mali is incapable of consistently providing grazing for Zebu cattle due to the presence of tsetse-borne trypanosomiasis. (Logan, et al., 1979.)

The great advantage of the Sahel as a breeding ground is that the pastures are virtually free from ticks and helminths which cannot survive on the arid desert land during the dry part of the year (Ormerod, 1976). Traditionally the Fulani trek their cattle northward in

July to make use of the 2-3 month period of rainfall in the Sahel so that they can drop their calves there.

Because of commercial pressures, the cattle population in the Sahel has tremendously increased. As a result, during the dry season, the Sahel cannot support large cattle populations and the breeders are forced to move their livestock in massive numbers to the southern regions in search of water, grazing land and commercial markets. The epizootiology of animal trypanosomiasis is thereby greatly influenced, and cattle become exposed to trypanosomiasis risk. Maclenann (1970), working in Nigeria, states that such cattle experience a degree of trypanosomiasis but can usually avoid serious consequences by leaving infested areas when the advent of rain makes possible their return to safer areas. Nevertheless, severe outbreaks of trypanosomiasis result from injudicious exposure to risk. The southern movement thus accounts for the occurrence of trypanosomiasis well outside the infested areas.

In addition to catering to transhumant cattle from the Sahel, the southern and western regions of Mali need to open new areas for cattle production in response to the rapidly expanding internal and external demands for animal protein. Although sufficient statistical evidence is not available, animal trypanosomiasis is expected to be widely distributed in the southern and western regions and is undoubtedly one of the major constraints on the effective development of cattle industry in Mali. According to Coulibaly and Diallo (1978), 1,092,000 of 3,886,000 cattle are exposed to the danger of trypanosomiasis infection. Trypanosomiasis is a particularly serious problem in the south of the country where the Zebu, Zebu-taurin and even the Ndama cattle are infected. Information from veterinarians in the field and from appropriate ministries

and institutions confirms that trypanosomiasis is the single most important limiting factor for increased cattle production in all zones (Okiwelu, et al., 1978).

As stated above, however, despite the recognition accorded to the importance of the disease, there is very little statistical evidence available to support this belief. The only information available is a general disease distribution map for West Africa (Monnet, 1954). It is too general to be of much value in evaluating the disease situation and for formulating any disease control strategy. In addition, Morel (1973) carried out a brief survey on trypanosome distribution in Mali. His survey was conducted in three weeks at 12 different sites collecting 37 blood samples only. Five were shown to be positive for T. congolense and two for T. vivax. Again, this work does not provide sufficient scientific evidence to gauge the real significance of the disease.

More recently, during the course of this work, Goodwin et al. reported their findings in 1980 on a bovine trypanosomiasis survey carried out on a limited scale in the country. Their study was mainly based on spot disease investigation in 10 different livestock project sites on various occasions. In most cases, their work was the result of a request for assistance in disease investigation by other livestock projects. They reported a predominance of T. vivax in cases of trypanosomiasis seen in Glossina palpalis-infested areas. In the far southern part of Mali, in the Yanfolila cercle, T. congolense accounted for the greatest number of cases, followed by T. vivax and mixed infections of the two. This area is heavily infested with G. morsitans. T. brucei was seen in cattle newly introduced into sites such as Tienfala and Djeguinina but was seen with less frequency at other sites.

Information obtained, though valuable, is meager, and the areas covered by the study are rather limited. The work has to be extended to other areas in order to obtain comprehensive information on the disease situation in the country. It is still necessary to pursue vigorously the three areas of activity in the field of trypanosomiasis in Mali as identified by Gruvel (1977). He suggested first that a survey of the disease be carried out in order to assess the disease situation in Mali. Secondly, he emphasized the need to establish a tsetse and trypanosomiasis research branch in Mali, mainly with local staff; and thirdly, he observed the paucity of recent research work in the country.

In an effort to remove the constraint of animal trypanosomiasis, the Government of the Republic of Mali chose three candidate zones in central Mali to investigate the possibilities of expansion of livestock production. After preliminary tsetse ground surveys, one of the zones, i.e., the Niger Valley, was selected for intensive and detailed studies (Okiwelu, et al., 1978). The work plan for the purpose, formulated by Okiwelu, et al. in 1979, emphasized the need for incorporating disease distribution studies in the area before any vector control program was undertaken.

In pursuance of the program suggested by Okiwelu et al., and in view of the paucity of information available, a detailed long-term work plan to investigate the extent and significance of the disease was submitted in September 1979 by the senior author, who joined the project as Protozoologist. Major objectives and terms of reference of this work plan were as follows:

- Determination of the extent and degree of trypanosomiasis challenge in various parts of the zone.

- Epizootiological investigation, including study of the distribution and relative prevalence of various species of trypanosomes responsible for the disease and the possible implication of transhumance in the spread of animal trypanosomiasis.

- Investigation of the host-parasite relationships with regard to virulence of various trypanosome species and strains. Factors like age and breed are to be taken into consideration.

- Season variation in the occurrence of the disease in relation to seasonal variations in the population densities of its vector.

In view of the priorities of the program, the very limited time available during the 1979 rainy season which was approaching its end, and the inadequacy of laboratory facilities and other resources, it was suggested that a survey of bovine trypanosomiasis based on thin and thick blood smears and lymph smears be launched immediately. Despite great effort, the work could not be started until the end of October 1979, thereby completely missing the rainy-season part of the field program. The field collection of samples continued on an irregular basis throughout the dry season and was completed in May 1980.

The rainy season collection of samples and relevant information was launched in July 1980 with a target to cover about 110 villages within the short span of the rainy season. Despite enormous difficulties in funding and transport, most of field work was completed by the end of November 1980. Laboratory examination continued concurrently throughout the period of study.

This document reports the status of bovine trypanosomiasis in Zone 1 (Niger Valley) during the dry and rainy seasons and compares the seasonal variation in its occurrence. Also presented is information obtained regarding incidence variation among sedentary and nomadic

herds, susceptibility of various breeds of cattle, incidence variation between two age groups of cattle, relative prevalence of various species of trypanosomes, bovine morbidity and mortality due to trypanosomiasis and trypanosomiasis in other livestock. Relative evaluation of three protozoological methods for the diagnosis of trypanosomiasis used in these studies is also reported. Some of the findings were reported earlier (Awan and Bouare, 1980).

CHAPTER II

MATERIALS AND METHODS

CHAPTER II

MATERIALS AND METHODS

A. Description of Zone 1

Zone 1 occupies an area of 19,271 km^2 and lies between 12°14' and 13°50'N and 5°48' and 8°16'W. The most prominent feature of the zone is its division into two halves by the river Niger from Bankoumana in the southwest to Markala in the northeast. Main tributaries are the Dlannin, the Dilamba and the Dlan in the north, and the Koba and the Faya in the south.

The upper, or northeastern, part of the zone has Sudanian savanna type vegetation whereas the northwestern and southwestern parts merge into the Sub-sudanian or Guinean type of vegetation.

There are eight forests of various sizes within the zone and three in close proximity to the boundaries of the zone.

There are two distinct seasons, i.e., a rather prolonged dry season, extending from November to May and a short rainy season, usually from June to October, with some variations. The zone lies between isohyets 762 mm and 1270 mm in the north and south respectively, with minimum rainfall of 100 mm.

The zone is one of the most developed areas of Mali, particularly with regard to communications, etc.

B. System of Sampling

Zone 1 was divided into five sectors for sample collection purposes. These sectors were designated as follows:

1. Northwestern sector
2. Southwestern sector
3. North-central sector
4. South-central sector
5. Eastern sector

A number of villages were selected in each sector, taking various topographical features into consideration. Efforts were made to select villages in such a way that the distance between any two villages did not exceed 10 to 15 kilometers. A few villages outside the defined boundaries of the zone were also selected. At times, the villages earmarked on field schedule for sampling could not be included because of impassable roads, lack of cooperation from cattle-breeders, or absence of cattle from a certain village. In such instances, an alternative village was selected.

The sectors and villages sampled during dry and rainy season surveys are shown in Figs. 1 and 2 respectively. The number of camping sites in each sector depended on the size of the sector and the distances involved to cover envisaged villages. In the dry season, the northwestern and southwestern sectors were covered from Bamako as a base, since the necessary camping equipment was not available. The first half of the north-central sector was covered from the camp erected at Doumba and the second half from Niamina. The first half of the south-central sector was covered from Fougani and the second from Baroueli. The eastern sector was covered from the camp erected at Nizana.

During the rainy-season survey, the northern villages of the northwestern sector were covered from the camp at Nomoubougou, and the villages in the southern and western parts of the sector were sampled using Ferentoumou as base camp. Sanankoroba was used as base for collections in the

southwestern sector. The north-central and south-central sectors were sampled from the same camp sites as in the dry season. Markala was used as a camp site for the eastern sector during the rainy-season survey.

Field collection of samples for the dry-season survey was conducted from October 1979 to May 1980, whereas the rainy-season collections were carried out from July 1980 to November 1980.

In both studies the northwestern sector was sampled first. It was followed by the southwestern, north-central, south-central and eastern sectors. The results on a sector basis are presented in the same order.

C. Cattle and Other Livestock Sampled

All cattle sampled were either Zebu (Mason, 1951) or Ndama. The third category of cattle frequently met in the zone was Bambara, commonly called Mere. Mere are the product of Ndama X Fulani Zebu. Sheep and goats encountered were the small Djallonké type.

Cattle and other livestock sampled in each village were held either in a kraal or in open space outside the village. Each animal had to be cast on the ground for lymph node puncture in order to make lymph node biopsy smears. This was usually accomplished with little effort since the animals were relatively docile.

Animals were randomly selected as far as possible, except that a few sick animals, if present in a herd, were included. Slides from such animals were marked accordingly.

A minimum of 50 cattle were sampled from each village, to the extent possible. Only a few sheep, goats, donkeys and horses were sampled, depending on their availability.

D. Field Sampling Techniques

1. Collection of Blood Smears

Thin and thick blood smears were collected from each of the animals sampled. Peripheral blood from the ear vein was used for the purpose.

Thin blood smears were immediately dried by waving them in the air and were then stored in slide boxes.

Two to three drops of blood were used to prepare a large thick smear. These smears were dried by keeping them flat, with smear side facing upward, in slide boxes. Slide boxes were kept closed to protect smears from dust, flies, and other insects. It took 10 to 15 minutes for thick blood smears to dry during the dry season. It took much longer during the rainy season.

2. Collection of Lymph Smears

In cattle, an additional lymph node biopsy smear was also collected from each animal. This was accomplished by puncturing either the pre-scapular or the pre-crural lymph gland. The smears thus collected were dried in the same way as thick blood smears.

Three types of smears collected from each head of cattle were given one corresponding serial number. Information regarding breed and age, in codes, was etched on slides. In the case of a sick animal, the letter "S" was etched on slides collected from it. A separate consignment of slides was prepared from each village using slide boxes which were clearly labeled and identified.

Lymph node biopsy smears were not collected from other livestock. A questionnaire specially designed to collect information on parameters such as herd composition and status, general condition of livestock, history of disease, morbidity and mortality, clinical signs and use

of trypanocidal drugs, etc., was filled out for each herd sampled.

A regular flow of smears collected from the field to the laboratory was maintained, more or less on a weekly basis. This flow was important not only to start laboratory examinations concurrently but also to prevent smears from aging and possibly deteriorating.

E. Laboratory Techniques

On arrival of specimens in the laboratory, each village was treated separately in order to avoid any possible mix-up of slides. Giemsa Stain was used for staining all three types of smears.

1. Staining of Blood Smears

Thin blood smears were fixed in Methanol for one minute and then stained in Giemsa Stain solution, strength 1:10, for 30 minutes, placing slides perpendicularly in rectangular staining dishes. Stained slides were briefly and gently rinsed in tap water before letting them dry.

Blood smears of normal thickness were directly immersed, without methanol fixation, in Giemsa Stain solution. This solution being aqueous, no prior de-hemoglobinization in distilled water was necessary in most cases. In some exceptionally thick smears, 1/2 to 1 minute lysis of erythrocytes in distilled water was required before they were immersed in stain solution. No prior fixation of thick smears was done, either by maintaining at 37°C overnight or heating over an electric lamp for a few minutes (Shute and Maryon, 1966). Unfixed thick smears reaching the laboratory after 7 to 10 days of collection withstood lysis perfectly well without any harm to the smears. These smears were then stained for 30 minutes in Giemsa Stain, strength 1:20, immersing them perpendicularly in rectangular staining dishes. These

dishes had to be shaken occasionally in order to disperse the accumulated hemoglobin. This procedure was only necessary when the un-lysed slides were stained directly in Giemsa Stain solution. After staining, the slides were briefly rinsed in a gentle flow of tap water.

2. Staining of Lymph Node Biopsy Smears

These were stained in exactly the same way as thin blood smears. After processing and staining, slides from each village were arranged in sequence from the 1st to the 50th head of cattle. Slides from other animals were also similarly arranged for each category of livestock. These slides were stored in empty cardboard boxes, awaiting examination.

3. Examination of Smears

All three categories of smears were examined under the microscope using a 10 x 100 oil-immersion objective. As a matter of routine, the thick blood smear from each animal was screened first. If this smear was found positive, the corresponding thin blood smear was thoroughly searched to find trypanosomes for morphological identification. The corresponding lymph node biopsy smear was then examined to determine its status. If the thick blood smear and the lymph node biopsy smear from a single animal were negative, the corresponding thin blood smear was not examined.

Identification of trypanosome species was invariably based on finding trypanosomes in the thin blood smears. If the thin blood smear was negative but the corresponding thick blood smear or lymph node biopsy smear or both were positive, the trypanosomes thus found were classed as unidentified (Godfrey and Killick-Kendrick, 1961).

Thick blood smears and lymph node biopsy smears were searched for at least five minutes each, and a minimum of

600 fields was examined before any smear was declared negative. The thin blood smear of the corresponding positive thick blood smear was searched for an additional five minutes in an effort to find trypanosomes for identification purposes.

CHAPTER III

RESULTS

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RESULTS

A. Relative Diagnostic Values of Three Methods Used

Thin and thick blood smears and lymph node biopsy smears were used in both seasons to survey the incidence of bovine trypanosomiasis in the zone. Table I shows the relative diagnostic values of the three methods used to detect positive cases of trypanosomiasis.

Before the relative diagnostic values are compared, it is important to recognize that in this analysis only those positive cases of bovine trypanosomiasis were included for which a complete combination of three smears was examined. This fact explains why the total number of positive cases shown in Table I is less than the total number given in the incidence of the disease (Table IV) and relative prevalence of various trypanosome species (Table XII).

It can be seen from Table I that on an overall basis, the highest number of positive trypanosomiasis cases in cattle was detected by lymph node biopsy smears in both investigations. The second most efficient were the thick blood smears, followed by the thin blood smears, the latter being least effective, especially in the dry-season investigation.

During the dry-season investigation, lymph node biopsy smears showed, on the average, 96.62 percent efficacy, followed by thick blood smears showing 86.51 percent. The thin blood smears were least efficient, showing a diagnostic value of 62.92 percent. A similar trend was seen in the rainy-season investigation. Average relative value of lymph node biopsy smears for the rainy season was 93.02 percent, followed by 90.69 percent and 84.88 percent exhibited by thick and thin blood smears respectively.

TABLE I

BOVINE TRYPANOSOMIASIS: RELATIVE DIAGNOSTIC VALUES OF THREE METHODS USED

Sector	Dry Season Survey				Rainy Season Survey			
	Total Positive Cases +	Blood		Lymph	Total Positive Cases +	Blood		Lymph
		Thin Smear Total Positive (Relative Value)	Thick Smear Total Positive (Relative Value)	Total Positive (Relative Value)		Thin Smear Total Positive (Relative Value)	Thick Smear Total Positive (Relative Value)	Total Positive (Relative Value)
Northwestern	37	24 (64.86)	35 (94.59)	37 (100.00)	56	45 (80.35)	48 (85.71)	52 (92.85)
Southwestern	22	12 (54.54)	16 (72.72)	20 (90.90)	63	59 (93.65)	60 (95.23)	63 (100.00)
North-Central	17	13 (76.47)	16 (94.11)	16 (94.11)	24	22 (91.66)	22 (91.66)	24 (100.00)
South-Central	13	7 (53.84)	10 (76.92)	13 (100.00)	26	18 (69.23)	24 (92.30)	18 (69.23)
Eastern	0	0	0	0	3	2 (66.66)	2 (66.66)	3 (100.00)
Overall (Zone 1)	89	56 (62.92)	77 (86.51)	86 (96.62)	172	146 (84.88)	156 (90.69)	160 (93.02)

+ Only cases where a combination of all three smears was examined were counted.

Despite superior values shown by lymph node biopsy smears in terms of the overall positive number of cases, there were instances, as can be noted from Table I, where thick blood smears were positive but their corresponding lymph node biopsy smears negative. A total of three such cases were observed in the dry season, and 12 in the rainy season. It should be noted that not a single incidence was observed in which the thin blood smear was positive while its corresponding thick blood smear was negative.

Sector-wide examination of the data reveals some significant variations in the relative diagnostic values of the three categories of smears. The first variable was observed in the north-central sector during the dry-season study where lymph node biopsy smears and thick blood smears showed overall equal diagnostic value.

In one of the 17 combinations, the thick blood smear was negative but its corresponding lymph node biopsy smear was positive. In a different combination, the reverse was the case, i.e., the blood smear was positive whereas its corresponding lymph node biopsy smear was negative.

The second exception was also noticed in the north-central sector, but during the rainy-season investigation. Here, thick and thin blood smears showed equal diagnostic value of 91.66 percent. Equal diagnostic values of thin and thick blood smears were also seen in the eastern sector during the rainy-season study. In both of these cases, lymph node biopsy smears were still the most efficient method of detection of positive cases.

The final variable was noticed in the south-central sector during the rainy-season study, wherein relative diagnostic value of lymph node biopsy smears was found to be inferior (69.23 percent) compared to thick blood smears (92.30 percent). Incidentally, in this instance, the relative diagnostic value of lymph node biopsy smears was

equal to the value exhibited by thin blood smears. In both cases the relative value was 69.23 percent.

Comparing the average values of three categories of smears between two seasons, it can be observed that thin and thick blood smears were relatively less efficient during the dry than during the rainy-season investigation. The difference was especially well marked between the comparative values of thin blood smears in two seasons. The average relative diagnostic value of thin blood smears during the dry-season study was 62.92 percent compared to 84.88 percent for the rainy season. This difference showed a net reduction of 21.96 percent in the diagnostic value of thin blood smears during the dry-season investigation.

B. Cattle and Other Livestock Sampled

The total number of cattle and other livestock sampled during the dry and rainy-season surveys is recorded in Tables II and III respectively. Altogether, a total of 7,300 cattle, 691 sheep, 516 goats, 160 donkeys and 18 horses were sampled.

An interesting trend in the distribution of three breeds of cattle, i.e., Ndama, Zebu and Mere, was seen in the zone. The majority of cattle in western areas were Ndama and Mere. Zebu were few in number in these areas. Ndama population decreased in inverse proportion to the Zebu population in northern and eastern areas of the zone. The decrease in Mere population was relatively gradual, marked by a sudden increase in the south-central sector and a sharp decline in the eastern sector.

This fluctuation of the three breeds of cattle in various areas of the zone is also reflected in cattle sampled during the two seasons (Tables II and III). It can be seen from Table II that a total of 483 Ndama were

TABLE II
CATTLE AND OTHER LIVESTOCK SAMPLED (DRY SEASON)

Sector	Cattle							Other Livestock			
	Adults			Calves			Total				
	Ndama	Zebu	Mere	Ndama	Zebu	Mere		Sheep	Goats	Donkeys	Horses
Northwestern	303	3	325	18	0	30	679	69	86	26	4
Southwestern	135	35	250	27	2	42	491	52	24	19	0
North-Central	23	304	177	1	124	39	668	111	107	40	4
South-Central	153	393	472	38	64	137	1277	179	115	36	2
Eastern	2	451	98	0	67	25	643	95	100	24	8
Total	616	1186	1322	84	277	273	3758	506	432	145	18

TABLE III
CATTLE AND OTHER LIVESTOCK SAMPLED (RAINY SEASON)

Sector	Cattle							Other Livestock			
	Adults			Calves			Total				
	Ndama	Zebu	Mere	Ndama	Zebu	Mere		Sheep	Goats	Donkeys	Horses
Northwestern	534	16	117	127	4	28	826	34	20	7	0
Southwestern	167	22	195	52	3	54	493	35	30	8	0
North-Central	13	354	87	0	103	19	576	102	34	0	0
South-Central	107	596	361	35	91	96	1286	14	0	0	0
Eastern	1	237	33	0	85	5	361	0	0	0	0
Total	822	1225	793	214	286	202	3542	185	84	15	0

sampled from the northwestern and southwestern sectors during the dry-season survey, whereas only 40 Zebu were available for sampling. On the other hand, only 217 Ndama were sampled in the north-central, south-central and eastern sectors, compared with 1,423 Zebu cattle. A total of 355 Mere were sampled in the northwestern sector, followed by 292 and 216 in the southwestern and north-central sectors respectively. A sudden increase in Mere cattle population in the south-central sector is reflected by the fact that a total of 609 Mere were sampled from this sector during the dry season. Mere population declined sharply in the eastern sector where only 123 animals of this breed were sampled.

A more or less similar feature was seen in the figures of the rainy-season survey. A total of 880 Ndama were sampled from northwestern and southwestern sectors compared to only 45 Zebu. On the other hand, 156 Ndama were sampled in the north-central, south-central, and eastern sectors as against 1,466 Zebu cattle. The number of Mere sampled in the northwestern sector was 145, followed by a slight increase in the southwestern sector, where 245 specimens of this breed were sampled. The number of Mere sampled in the north-central sector was 106, followed by 457 in the south-central sector. The number of Mere fell sharply in the eastern sector, where only 38 cattle of this breed were sampled (Table III).

It is important to note that the number of cattle sampled during both seasons was roughly proportional to the number of various breeds of cattle available in a particular herd.

C. Bovine Trypanosomiasis

1. Incidence and Pattern of Distribution

Before any conclusion on the incidence of the disease is presented, it is important to explain the

criterion adopted to present the data with regard to mixed infections. In all presentations below, except in the analysis for relative prevalence of various trypanosome species, each mixed infection was treated as a single entity, regardless of whether it was composed of two or even three species of pathogenic trypanosomes. It was essential to do so in order to present an accurate picture of the occurrence of the disease.

The species of pathogenic trypanosomes recorded were, in the order of their prevalence, Trypanosoma vivax, T. congolense, and T. brucei. T. theileri, a non-pathogenic trypanosome, was frequently encountered in both seasons, but was not taken into consideration in this analysis.

a. Overall Incidence

Altogether, 307 positive cases of bovine trypanosomiasis were confirmed in the laboratory during both seasons. This number was out of a total of 7,300 cattle examined, showing an overall average disease incidence of 4.20 percent in the zone.

b. Incidence in the Dry Season

One hundred and seventeen trypanosomiasis cases were detected among the 3,758 cattle examined during the study, showing a dry-season disease incidence of 3.11 percent in the zone.

The incidence of bovine trypanosomiasis on a village basis is provided in Figures 1 and 3. Figure 1 provides the total number of cattle sampled and the total found positive for each village in the dry season. Percent positive for each village is also given in parenthesis. In Figure 3, each solid black diamond represents one case of bovine trypanosomiasis detected during the dry-season survey.

The incidence of the disease on a sector basis among the various villages, herds and cattle examined is given in Table IV. Appraisal of Figures 1 and 3 and Table IV reveals the following salient features.

(1) Northwestern Sector

Fourteen villages, viz., Farabana, Samankou, Dyeliba, Kamale, Bankoumana, Dango, Komi-Komi, Kalifabougou, Noumoubougou, Serouala, Dogoni (Feya), Semma, Koulouninkoro and Dourako were sampled. All of them showed varying degrees of trypanosomiasis. The maximum number of cases was recorded at Farabana, showing 48.0 percent infection. The minimum infection rate recorded was at Dyeliba, Koulouninkoro, and Dourako, where 2.0 percent of the cattle examined were found harboring trypanosomes.

Twenty-four of the 43 herds of cattle sampled were found infected, showing a herd incidence of the disease of 55.81 percent, with 9.27 percent of the cattle showing peripheral parasitaemia with pathogenic trypanosomes.

(2) Southwestern Sector

Eight of the ten villages sampled exhibited cattle with varying degrees of peripheral parasitaemia. The villages sampled were: Dougourakoro, Kokoun, Manankoroni, Mounzou, Nyoko, Kabe, Bala, Digato, Bougoula and Tyele. Dougourakoro and Nyoko were negative. Among the eight positive villages. Tyele and Mounzou showed the highest infection of 10.0 percent. Herd incidence was 57.89 percent, and 4.68 percent of the cattle examined in the sector were found positive with pathogenic trypanosomes.

(3) North-central Sector

Out of a total of 18 villages sampled, 10 were found positive showing a village disease incidence

TABLE IV

BOVINE TRYPANOSOMIASIS: INCIDENCE IN VILLAGES, HERDS AND CATTLE EXAMINED

Sector	Dry-Season Survey			Rainy-Season Survey		
	Village	Herds	Cattle	Village	Herds	Cattle
	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)
Northwestern	14/14 (100.00)	24/43 (55.81)	63/679 (9.27)	17/20 (85.00)	30/42 (71.42)	66/826 (7.99)
Southwestern	8/10 (80.00)	11/19 (57.89)	23/491 (4.68)	11/11 (100.00)	16/18 (88.88)	69/493 (13.99)
North-Central	10/18 (55.55)	12/35 (34.28)	18/668 (2.69)	9/16 (56.25)	8/20 (40.00)	26/576 (4.51)
South-Central	6/31 (19.35)	6/68 (8.82)	13/1277 (1.01)	10/30 (33.33)	11/74 (14.86)	26/1286 (2.02)
Eastern	0/17 (0.0)	0/25 (0.0)	0/643 (0.0)	1/9 (11.11)	1/28 (3.57)	3/361 (0.83)
Overall (Zone 1)	38/90 (42.22)	53/190 (27.89)	117/3758 (3.11)	48/86 (55.81)	66/182 (36.26)	190/3542 (5.36)

of 55.55 percent. The villages sampled were Nomobougou, Dougouni, Niamakorobougou, Sindo, Dlana, Tafala, Monzonbala, Doumba, Kondo, Konabougou, Tougouni, Gouenindo, Segala, Bananble, Tienle, Saï, Soulinga and Niamina. Positive villages were Nomobougou, Dougouni, Niamakorobougou, Sindo, Dlana, Tafala, Monzonbala, Kondo, Tougouni and Segala. The highest infection rate of 10.0 percent was recorded at Kondo, whereas the lowest was at Nomobougou, Monzonbala, Dougouni, Tafala and Sindo where only 2.0 percent of the cattle sampled showed infections.

Positive herd and cattle incidence in the sector were 34.28 percent and 2.69 percent respectively.

(4) South-central Sector

A total of 31 villages was sampled. Only six of them were found infected, showing infected village incidence of 19.35 percent. The villages sampled were: Fougani, Sougouna, Tombo, Banankabougou, Missango, Sirimou, Ngolobala, Nenyele, Bakoule, Koni, Kourokoro, Sokoro, Dyoumasana, Nieke, Baroueli, Deni, Tyenabougou, Soukoungo, Soïa, Ouolokoro, Diako, Mantola, Koulala, Djila, Kanba, Dogona, Kamini, Nango, Niama (Ngama), Kassa and Daolabougou. Of these, Nenyele, Sokoro, Baroueli, Ouolokoro, Mantola and Kassa were found infected. Among infected villages, the maximum infection rate was recorded at Nenyele (12.0 percent) and the minimum was at Ouolokoro and Mantola (2.0 percent).

Herd incidence of the disease was 8.82 percent in the sector, and 1.01 percent of the cattle showed infection.

(5) Eastern Sector

A total of 17 villages, viz., Nazana, Kaban, Foulabougou, Kala, Kobi, Samaflala, Sagala, Ounenbougou, Boussin, Oueta, Dongoma, Diaskoro, Bale, Binatomabougou, Pedia Were (Amdalay), Dialabougou and Togo were sampled. None of them showed any infection. Note

that villages Boussin and Dongoma do not appear on the maps (Figures 1 and 3).

In conclusion, 100.0 percent of the villages were found infected in the northwestern sector, 80.0 percent in the southwestern sector, 55.55 percent in the north-central sector and 19.35 percent in the south-central sector. None of the villages in the eastern sector showed any infection (Table IV).

The highest incidence of the disease, on a herd and cattle basis, was recorded in the northwestern and southwestern sectors. Incidence declined significantly and sharply in the north-central and south-central sectors respectively and none of the 643 cattle were found infected in the eastern sector. The overall dry-season incidences in the zone on the basis of village, herd, and cattle were 42.22 percent, 27.89 percent and 3.11 percent respectively.

c. Incidence in the Rainy Season

A total of 190 cases of bovine trypanosomiasis were recorded among 3,542 cattle examined, bringing the rainy-season incidence of the disease to 5.36 percent.

The incidence of the disease on a village basis is provided in Figures 2 and 3. Figure 2 carries details of the number of cattle sampled and the number found positive from each village, percent positives being given in parentheses. In Figure 3, each solid star represents one case of bovine trypanosomiasis detected during the rainy-season survey. The incidence of the disease among various villages, herds and cattle examined is also incorporated in Table IV, on a sector basis. Examination of Figures 2, 3 and Table IV reveals the following salient features of the disease during the rainy-season study.

(1) Northwestern Sector

A total of 20 villages, viz., Farabana, Samanko, Dyeliba, Kamale, Bankoumana, Dango, Komi-Komi, Kalifabougou, Noumoubougou, Serouala, Dogoni (Feya), Semma, Dourako, Kodian, Soniebougou, Kambila, Faraba, Sikorobougou, Sotoli and Degueta was sampled. Seventeen of the 20 villages sampled showed cattle with varying degrees of peripheral parasitaemia with pathogenic trypanosomes. These villages were Farabana, Samanko, Dyeliba, Kamale, Bankoumana, Dango, Komi-Komi, Kalifabougou, Noumoubougou, Serouala, Semma, Dourako, Kodian, Faraba, Sikorobougou, Sotoli and Degueta. The maximum infection rate was recorded at Kamale (24.0 percent) with 8.6 to 19.4 percent incidence in the surrounding villages of Dango, Faraba, Samanko, Farabana, Dyeliba and Bankoumana. The minimum infection rate among positive villages was at Kodian (2.9 percent) in the northern part of the sector.

The incidence of the disease on a herd and cattle basis was 71.42 percent and 7.99 percent respectively in the sector.

(2) Southwestern Sector

All of the 11 villages sampled were found to be infected. These villages were Dougourakoro, Kokoun, Manankoroni, Mounzou, Nyoko, Kabe, Digato, Bougoula, Tyele, Sanankoroba and Dyoumana. The maximum infection rate was seen at Manankoroni (34.0 percent) and the minimum at Dougourakoro (4.0 percent). The herd incidence was 88.88 percent and incidence among cattle was 13.99 percent.

(3) North-central Sector

Sixteen villages, viz. Nomobougou, Dougouni, Niamakorobougou, Sindo, Dlana, Doumba,

Konabougou, Tougouni, Gouenindo, Segala, Banable, Saï, Soulinga, Niamina, Doerebougou and Kerouane were sampled. Nine of the villages, i.e. Nomobougou, Dougouni, Sindo, Dlana, Konabougou, Tougouni, Gouenindo, Saï and Niamina were found infected, bringing the village incidence to 56.25 percent. The maximum infection rate was in the village Saï (28.0 percent), where seven of the 25 cattle sampled were found infected. The minimum infection rate (2.0 percent) was recorded in Sindo. The herd incidence of the disease was 40.0 percent, while 4.51 percent of the cattle were found to be infected in the sector.

(4) South-central Sector

A total of 30 villages, viz., Fougani,Sougouna, Tombo, Banankabougou, Missango, Sirimou, Ngolobala, Nenyele, Bakoule, Koni, Kouroukoro, Sokoro, Dyoumasana, Nieke, Baroueli, Deni, Tyenabougou, Sokoungo, Soïa, Ouolokoro, Diako, Mantola, Koulala, Djila, Kanba, Dogona, Kamini, Nango, Kassa and Daolabougou were sampled. Ten of the villages, i.e., Fougani, Nenyele, Sokoro, Baroueli, Deni, Ouolokoro, Mantola, Koulala, Dogona and Kassa were found to be infected, bringing the percentage of villages infected to 33.33 percent. The maximum infection rate was recorded in Dogona (16.7 percent) and the minimum in Baroueli (2.0 percent). The herd incidence of the disease was 14.86 percent, while 2.02 percent of the cattle sampled were found infected in the sector.

(5) Eastern Sector

Nine villages, viz., Kaban, Foulabougou, Kala, Binatomabougou, Pedia Were (Amdalay), Dialabougou, Togo, Markala and Masala were sampled. Only one of the villages, i.e., Foulabougou, was found to be infected, bringing the percentage of villages found infected to 11.11 percent.

The herd disease incidence was 3.57 percent, while 0.83 percent of the cattle sampled were found to be infected.

In conclusion, 85.0 percent of the villages in the northwestern sector and 100.0 percent of the villages in the southwestern sector were found to be infected. The village incidence in the north-central sector declined to 56.25 percent with a further decline to 33.33 per cent in the south-central sector. In the eastern sector, the village disease incidence was 11.11 percent.

Similarly, the highest disease incidence on a herd and cattle basis was recorded in the northwestern and southwestern sectors with a progressive decrease in the remaining sectors.

The overall rainy-season incidence in the zone was 55.81 percent, 36.26 percent and 5.36 percent on a village, herd, and cattle basis respectively.

d. Seasonal Variation in the Incidence of the Disease

Out of a grand total of 307 positive cases of bovine trypanosomiasis, 117 were detected during the dry season and 190 were picked up during the rainy-season investigation. These were among 3,758 and 3,542 cattle examined during the dry and rainy seasons respectively.

Thus, the incidence of the disease was 3.11 percent in the dry season and 5.36 percent in the rainy season (Table IV). In other words, incidence of the disease was higher by 2.25 percent in the rainy season compared with the incidence in the dry period. A comparison of Figures 1 and 2, an appraisal of Figure 3, and study of comparative Table IV clearly shows a significant general increase in the disease situation during the rainy season.

The only exception to this generalization was the northwestern sector where the average incidence for the sector was slightly higher in the dry than in the rainy season. This may be due to the fact that the dry-season studies were started during the last week of October 1979 when the rains were just ending. Moreover, it was an unusually prolonged rainy season and the higher incidence of the disease recorded in at least some of the villages of the northwestern sector seems to be due to continued vector activity as a result of the rains. A comparison of Figures 1 and 2 demonstrates that the disease situation at the village Farabana alone can be largely held responsible for the relative increase in the disease incidence in the sector during the dry season. This village was the first village sampled for the dry-season investigation during the end of October 1979 when the prolonged rainy season had not yet completely ended. Moreover, this village was sampled during the scene of an outbreak of animal trypanosomiasis.

In all other sectors, a distinct and significant overall increase in the incidence of the disease was observed in the rainy season compared with the dry-season situation (Table IV).

Figures 1, 2 and 3 provide the opportunity to evaluate seasonal variation of the disease at a village level. For easy comprehension this situation is also described as follows, considering each sector separately.

(1) Northwestern Sector

A total of 14 villages were sampled during the dry season, and 20 during the rainy season. Among these, 13 villages were sampled during both seasons. These, considered as "twin villages," were Farabana, Samanko, Dyeliba, Kamale, Bankoumana, Dango, Komi-Komi, Kalifabougou, Noumoubougou, Serouala, Dogoni

(Feya), Semma, and Dourako. The remaining villages were either sampled in the dry or in the rainy season only, hence comparative disease data for them is not available.

The incidence of the disease in cattle, as obtained during both the seasons in each of the 13 twin villages, is tabulated in Table V in order to compare seasonal variation at the village level.

It can be seen from the table that seven of the 13 twin villages showed a higher incidence of the disease in the rainy season compared with the dry season. These villages were Samanko, Dyeliba, Kamale, Bankoumana, Komi-Komi, Serouala and Dourako. Two of the villages, Semma and Noumoubougou, showed parallel infection rates. In three villages, Farabana, Dango and Kalifabougou, the infection rates in the rainy season were lower than in the dry season, and one of the villages, Dogoni (Feya), was negative in the wet season but positive in the dry.

The comparatively higher incidence of the disease in three of the villages during the dry season may well be due to activity of the vector as explained above. The negative status of the village Dogoni (Feya) may be due to trypanocidal treatments the animals might ha e received prior to sampling.

(2) Southwestern Sector

A total of 10 villages were sampled during the dry and 11 during the rainy season. Nine of these were twin villages, i.e., they were sampled during both seasons. These villages were Dougourakoro, Kokoun, Manankoroni, Mounzou, Nyoko, Kabe, Digato, Bougoula and Tyele. Of the remaining villages, Bala was sampled in the dry season, while Sanankoroba and Dyoumana were sampled in the rainy season.

TABLE V
SEASONAL VARIATION IN THE INCIDENCE OF BOVINE TRYPANOSOMIASIS, NORTHWESTERN SECTOR

Serial Number	Village	Dry Season		Rainy Season	
		Total Positive/ Total Examined	Percent Positive	Total Positive/ Total Examined	Percent Positive
1	Farabana	24/50	48.0	2/15	13.33
2	Samanko	3/50	6.0	2/15	13.33
3	Dyeliba	1/50	2.0	5/50	10.0
4	Kamale	5/50	10.0	12/50	24.0
5	Bankoumana	3/50	6.0	5/50	10.0
6	Dango	4/29	13.79	3/35	8.57
7	Komi-Komi	4/50	8.0	5/48	10.41
8	Kalifabougou	4/50	8.0	3/50	6.0
9	Noumoubougou	6/50	12.0	6/50	12.0
10	Serouala	2/50	4.0	3/50	6.0
11	Dogoni (Feya)	3/50	6.0	0/30	0.0
12	Semma	2/50	4.0	2/50	4.0
13	Dourako	1/50	2.0	3/37	8.1

Details of the disease incidence in the nine twin villages during both seasons is tabulated in Table VI for evaluation of the variation in disease occurrence at the village level in this sector.

As can be seen from Table VI, of the nine twin villages, Dougourakoro and Nyoko were negative in the dry season whereas the disease incidence in these villages was 4.0 percent and 14.28 percent respectively during the rainy-season investigation. In six of the nine twin villages, i.e., Manankoroni, Mounzou, Kabe, Digato, Bougoula and Tyele, the disease incidence was found to increase during the rainy season. In some of the villages, the incidence was more than double in the rainy season compared to the dry season. In one of the nine twin villages, i.e. Kokoun, the incidence was 4.0 percent lower in the rainy season than in the dry. The decrease could either be due to use of trypanocidal drugs prior to sampling in the rainy season or could be due to the presence of a large number of sub-patent infections which were difficult to detect by the methods deployed in the surveys.

(3) North-central Sector

Of a total of 18 and 16 villages sampled during the dry and rainy seasons respectively, 14 were twin villages. These were Nomobougou, Dougouni, Niamakorobougou, Sindo, Dlana, Doumba, Konabougou, Tougouni, Gouenindo, Segala, Bananble, Saï, Soulinga and Niamina. Tafala, Monzonbala, Kondo and Tienle were sampled in the dry season and Doerebougou and Kerouane during the rainy season only.

The disease incidence in cattle during the two seasons in 14 twin villages is tabulated in Table VII. As can be seen from the table, nine of the 14 twin villages, viz., Nomobougou, Dougouni, Sindo, Dlana, Konabougou, Tougouni,

TABLE VI
SEASONAL VARIATION IN THE INCIDENCE OF BOVINE TRYPANOSOMIASIS, SOUTHWESTERN SECTOR

Serial Number	Village	Dry Season		Rainy Season	
		Total Positive/ Total Examined	Percent Positive	Total Positive/ Total Examined	Percent Positive
1	Dougourakoro	0/50	0.0	2/50	4.0
2	Kokoun	5/50	10.0	3/50	6.0
3	Manankoroni	2/50	4.0	17/50	34.0
4	Mounzou	5/50	10.0	10/50	20.0
5	Nyoko	0/41	0.0	5/35	14.28
6	Kabe	2/50	4.0	3/50	6.0
7	Digato	1/50	2.0	6/33	18.18
8	Bougoula	2/50	4.0	2/25	8.0
9	Tyele	5/50	10.0	16/50	32.0

TABLE VII
SEASONAL VARIATION IN THE INCIDENCE OF BOVINE TRYPANOSOMIASIS, NORTH-CENTRAL SECTOR

Serial Number	Village	Dry Season		Rainy Season	
		Total Positive/ Total Examined	Percent Positive	Total Positive/ Total Examined	Percent Positive
1	Noumoubougou	1/50	2.0	1/25	4.0
2	Dougouni	1/50	2.0	3/50	6.0
3	Niamakorobougou	1/25	4.0	0/25	0.0
4	Sindo	1/50	2.0	1/50	2.0
5	Dlana	4/46	8.69	2/35	5.71
6	Doumba	0/50	0.0	0/50	0.0
7	Konabougou	0/15	0.0	2/25	8.0
8	Tougouni	2/50	4.0	3/50	6.0
9	Gouenindo	0/30	0.0	2/50	4.0
10	Segala	1/30	3.33	0/15	0.0
11	Bananble	0/26	0.0	0/30	0.0
12	Sai	0/21	0.0	7/25	28.0
13	Boulinga	0/25	0.0	0/26	0.0
14	Niamina	0/25	0.0	5/20	25.0

Gouenindo, Saï and Niamina, were found to be positive in the rainy season as against seven, i.e., Nomobougou, Dougouni, Niamakorobougou, Sindo, Dlana, Tougouni and Segala during the dry-season investigation. Four of the nine rainy-season positive villages, i.e., Konabougou, Gouenindo, Saï and Niamina, showed infection in the rainy season only. One of the nine villages, i.e., Sindo, had equal incidence levels during both seasons; three, i.e., Nomobougou, Dougouni and Tougouni were higher, and one, Dlana, had lower incidence in the rainy season as compared with the dry season. Among seven dry-season positive villages, two, Niamakorobougou and Segala were, however, negative during the rainy season.

It is important to mention that of the 14 twin villages, three, Doumba, Bananble, and Soulinga, were negative in both seasons.

(4) South-central Sector

Among 31 and 30 villages sampled during the dry and rainy seasons respectively, 30 were twin villages. These were Fougani, Sougouna, Tombo, Banankabougou, Missango, Sirimou, Ngolobala, Nenyele, Bakoule, Koni, Kouroukoro, Sokoro, Dyoumasana, Nieke, Baroueli, Deni, Tyenabougou, Soukoungo, Soïa, Ouolokoro, Diako, Mantola, Koulala, Djila, Kanba, Dogona, Kamini, Nango, Kassa and Daolabougou. Niama (Ngama) was sampled in the rainy season only.

Table VIII provides comparative data on the incidence of the disease in 30 twin villages of the sector in both seasons. As can be observed from the table, among 30 twin villages, 10 villages, viz., Fougani, Nenyele, Sokoro, Baroueli, Deni, Ouolokoro, Mantola, Koulala, Dogona and Kassa were positive during the rainy-season investigations. On the other hand, only six of the 30 twin villages showed evidence of the disease in the dry

TABLE VIII
SEASONAL VARIATION IN THE INCIDENCE OF BOVINE TRYPANOSOMIASIS, SOUTH-CENTRAL SECTOR

Serial Number	Village	Dry Season		Rainy Season	
		Total Positive/ Total Examined	Percent Positive	Total Positive/ Total Examined	Percent Positive
1	Fougani	0/34	0.0	3/25	12.0
2	Sougouna	0/50	0.0	0/51	0.0
3	Tombo	0/50	0.0	0/40	0.0
4	Banankabougou	0/37	0.0	0/30	0.0
5	Missango	0/50	0.0	0/40	0.0
6	Sirimou	0/50	0.0	0/40	0.0
7	Ngolobala	0/50	0.0	0/50	0.0
8	Nenyele	6/50	12.0	2/50	4.0
9	Bakoule	0/30	0.0	0/30	0.0
10	Koni	0/40	0.0	0/35	0.0
11	Kouroukoro	0/45	0.0	0/30	0.0
12	Sokoro	2/50	4.0	3/35	8.57
13	Dyoumasana	0/50	0.0	0/50	0.0
14	Nieke	0/50	0.0	0/50	0.0
15	Baroueli	2/50	4.0	1/50	2.0
16	Deni	0/50	0.0	2/48	4.16
17	Tyenabougou	0/43	0.0	0/49	0.0
18	Soukoungo	0/50	0.0	0/50	0.0
19	Soia	0/50	0.0	0/51	0.0

TABLE VIII (cont'd.)

Serial Number	Village	Dry Season		Rainy Season	
		Total Positive/ Total Examined	Percent Positive	Total Positive/ Total Examined	Percent Positive
20	Ouolokoro	1/50	2.0	2/50	4.0
21	Diako	0/50	0.0	0/50	0.0
22	Mantola	1/50	2.0	6/50	12.0
23	Koulala	0/50	0.0	3/50	6.0
24	Djila	0/28	0.0	0/50	0.0
25	Kanba	0/22	0.0	0/50	0.0
26	Dogona	0/7	0.0	1/6	16.67
27	Kamini	0/2	0.0	0/50	0.0
28	Nango	0/19	0.0	0/50	0.0
29	Kassa	1/28	3.57	3/26	11.53
30	Daolabougou	0/50	0.0	0/50	0.0

season. These villages were Nenyele, Sokoro, Baroueli, Ouolokoro, Mantola and Kassa.

Of 10 rainy-season positive villages, four, Fougani, Deni, Koulala, and Dogona, were negative during the dry season study. Four of the villages, Sokoro, Ouolokoro, Mantola and Kassa, showed much higher disease incidence in the rainy compared with the dry-season survey. The two remaining villages, Nenyele and Baroueli, however, showed lower incidence of the disease in the rainy than in the dry season. None of the villages which was positive in the dry season was negative in the rainy-season study.

It is interesting to note that 20 of the 30 twin villages were negative during both seasons.

(5) Eastern Sector

Among 17 and nine villages sampled during the dry and rainy seasons respectively, seven were twin villages. These were Kaban, Foulabougou, Kala, Binatomabougou, Pedia Were (Amdalay), Dialabougou and Togo.

One of the seven twin villages, Foulabougou, was found infected and that in the rainy season only.

In conclusion, it can be seen that the incidence of the disease even at village level, taking into account the variations outlined above, was comparatively higher in the rainy season than in the dry.

e. Disease Delineation and its Extent in the Zone

From the details of the incidence provided above, it can be deduced that bovine trypanosomiasis is endemic in the northwestern sector. The disease was detected in significant numbers in most villages examined during both seasons (Figures 1, 2, 3). A higher incidence of the disease was observed with greater disease precipitation in villages in the vicinity of forest

reserves or near the river bank (Figure 3). As can be seen from this Figure, high incidence was recorded in Farabana, Samanko, Faraba, Kamale, Dyeliba and Bankoumana. Most of these villages were in or around the Forêt Classée des Monts Mandingues and some of them were very near the river bank.

A more or less similar trend was seen in the southwestern sector. Generally, higher incidence and endemicity of the disease was observed in the southern and western parts of the sector. The relationship between the forest reserve and the disease was particularly noticed in Koukoun and Mounzou (Figure 3).

In the north-central and south-central sectors of the zone, the distribution of the disease was found to be rather patchy, with some seasonal variations and higher concentration around forest reserves. Noticeable examples were the villages Niamina in the north-central sector and Kassa, Mantola, Baroueli and Ouolokoro in the south-central sector. Small permanent foci of the disease were also seen to be present along the river Niger and its main tributaries. Examples were villages Dlana, Dougouni, Sindo and Tougouni in the north-central and Nenyele and Kassa in the south-central sector (Figure 3). Complete absence of the disease in 20 of the 30 twin villages of the south-central sector during both seasons was striking.

In the eastern sector, permanent foci of the disease appeared to be absent and the incidence at Foulabougou during the rainy season seemed sporadic.

f. Incidence Variation among Sedentary and Nomadic Herds

Out of a total of 190 herds of cattle examined during the dry season, 158 were sedentary and 32 were nomadic. Incidence of the disease on a herd basis was 37.50 percent in nomadic herds, as against 24.68

percent in sedentary herds. In other words, the herd incidence of the disease was igher in nomadic than in sedentary herds of cattle during the dry-season investigation. A similar trend was seen on a sector basis without any exception (Table IX).

Contrary to the above, however, it can be noticed in figures of the rainy-season investigation (Table IX), the average herd incidence of the disease was 41.78 percent in sedentary and 13.88 percent in nomadic herds. The variation on a sector basis was, however, inconstant. The incidence variation pattern in the south-central sector conformed to the overall rainy-season situation and all nine nomadic herds examined in the eastern sector were negative. On the other hand, in the north-central sector herd incidence of the disease was higher in nomadic herds (66.66 percent) than in sedentary herds (35.29 percent).

g. Susceptibility of Various Breeds of Cattle

During the dry-season investigation, Zebu were found to be most susceptible to animal trypanosomiasis in the northwestern, southwestern, and north-central sectors (Table X). This breed was followed by Mere in susceptibility in these areas. Ndama were found to be least susceptible. In the south-central sector, susceptibility to infection was noticed to be slightly greater in Mere than in Zebu. All 191 Ndama examined in the sector were negative. The average trend in the zone during the dry season, however, changed. In average figures for the dry season, 4.20 percent susceptibility was shown by Mere, 3.42 percent by Ndama and 1.77 percent by Zebu (Table X).

During the rainy-season investigation, Zebu showed the highest susceptibility in the northwestern, southwestern and north-central sectors (Table X). In the northwestern sector, Ndama were slightly more susceptible than Mere,

TABLE IX

BOVINE TRYPANOSOMIASIS: INCIDENCE VARIATION AMONG SEDENTARY AND NOMADIC HERDS

Sector	Dry Season Survey			Rainy Season Survey		
	Herds Examined			Herds Examined		
	Sedentary	Nomadic	Total	Sedentary	Nomadic	Total
	Positive / Examined (Percent Positive)	Positive / Examined (Percent Positive)	Positive / Examined (Percent Positive)	Positive / Examined (Percent Positive)	Positive / Examined (Percent Positive)	Positive / Examined (Percent Positive)
Northwestern	24/43 (55.81)	0 (0)	24/43 (55.81)	30/42 (71.42)	0 (0)	30/42 (71.42)
Southwestern	9/17 (52.94)	2/2 (100.00)	11/19 (57.89)	16/18 (88.88)	0 (0)	16/18 (88.88)
North-Central	3/19 (15.78)	9/16 (56.25)	12/35 (34.28)	6/17 (35.29)	2/3 (66.66)	8/20 (40.00)
South-Central	3/54 (5.55)	1/14 (7.14)	4/68 (5.88)	8/50 (16.00)	3/24 (12.50)	11/74 (14.86)
Eastern	0/25 (0.0)	0/0 (0.0)	0/25 (0.0)	1/19 (5.26)	0/9 0.0	1/28 (3.57)
Overall (Zone 1)	39/158 (24.68)	12/32 (37.50)	51/190 (26.84)	61/146 (41.78)	5/36 (13.88)	66/182 (36.26)

TABLE X

BOVINE TRYPANOSOMIASIS: SUSCEPTIBILITY OF VARIOUS BREEDS

Sector	Dry Season Survey			Rainy Season Survey		
	Breeds of Cattle			Breeds of Cattle		
	Ndama	Zebu	Mere	Ndama	Zebu	Mere
	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)
Northwestern	22/321 (6.85)	1/3 (33.33)	40/355 (11.26)	50/661 (7.56)	6/20 (30.00)	10/145 (6.89)
Southwestern	2/162 (1.23)	6/37 (16.21)	15/292 (5.13)	14/219 (6.39)	15/25 (60.00)	40/249 (16.06)
North-Central	0/24 (0.0)	15/428 (3.50)	3/216 (1.38)	0/13 (0.0)	22/457 (4.81)	4/106 (3.77)
South-Central	0/191 (0.0)	4/477 (0.83)	9/609 (1.47)	1/42 (0.70)	13/687 (1.89)	12/457 (2.62)
Eastern	0/2 (0.0)	0/518 (0.0)	0/123 (0.0)	0/1 (0.0)	3/322 (0.93)	0/38 (0.0)
Overall (Zone 1)	24/700 (3.42)	26/1463 (1.77)	67/1595 (4.20)	65/1036 (6.27)	59/1511 (3.90)	66/995 (6.63)

but in the southwestern and north-central sectors, Mere ranked second to Zebu in their susceptibility to the disease. In the south-central sector, Mere showed slightly higher susceptibility, followed by Zebu and Ndama, the latter being least susceptible. In the eastern sector, Zebu was the only breed found to be infected. The overall picture for the zone during the rainy season also changed. The average order of susceptibility which emerged was: Mere (6.63 percent), Ndama (6.27 percent), and Zebu (3.90 percent)(Table X).

h. Incidence Variation Between Two Age Groups of Cattle

Two age groups were sampled during both studies. Cattle below six months of age were classed as calves, and those three years or over as adults. The variation of disease incidence observed in these two age groups in the zone during the dry and rainy-season studies is recorded in Table XI. As can be seen from this table, a clear-cut difference in susceptibility of the two age groups was shown during both seasons. Calves were found to be relatively more resistant than adults. During the dry season, on an average, 1.41 percent of the calves were found infected as against 3.45 percent of the adults. No variation was observed even on a sector basis.

A similar trend, without any exception, was also observed during the rainy-season investigation (Table VII).

2. Relative Prevalence of Various Trypanosome Species

The data presented in Table XII and simultaneously projected in histograms and maps (Figures 4-9) are slightly different from the data used to analyze the incidence of bovine trypanosomiasis in the zone. In those data, each mixed infection was taken as a single entity regardless of the number of trypanosome species involved in a particular animal. The total number of positive

TABLE XI

BOVINE TRYPANOSOMIASIS: INCIDENCE VARIATION BETWEEN TWO AGE GROUPS

Sector	Dry Season Survey			Rainy Season Survey		
	Total Positive Cases	Adults Total Positive/ Total Examined (Percent Positive)	Calves Total Positive/ Total Examined (Percent Positive)	Total Positive Cases	Adults Total Positive/ Total Examined (Percent Positive)	Calves Total Positive/ Total Examined (Percent Positive)
Northwestern	63	62/631 (9.82)	1/48 (2.08)	66	61/667 (9.14)	5/159 (3.14)
Southwestern	23	21/420 (5.00)	2/71 (2.81)	69	68/384 (17.70)	1/109 (0.91)
North-Central	18	14/504 (2.77)	4/164 (2.43)	26	25/454 (5.50)	1/122 (0.81)
South-Central	13	11/1018 (1.08)	2/259 (0.77)	26	23/1064 (2.16)	3/222 (1.35)
Eastern	0	0/551 (0.0)	0/92 (0.0)	3	3/271 (1.10)	0/90 (0.0)
Overall (Zone 1)	117	108/3124 (3.45)	9/634 (1.41)	190	180/2840 (6.33)	10/702 (1.42)

TABLE XII

BOVINE TRYPANOSOMIASIS: RELATIVE PREVALENCE OF TRYPANSOME SPECIES

	Dry Season Survey					Rainy Season Survey				
	Total Positive Cases	Species Distribution				Total Positive Cases	Species Distribution			
		T. vivax Total Positive (Species Percentage)	*T. congolense* Total Positive (Species Percentage)	*T. brucei* Total Positive (Species Percentage)	Unidentified Total Positive (Species Percentage)		*T. vivax* Total Positive (Species Percentage)	*T. congolense* Total Positive (Species Percentage)	*T. brucei* Total Positive (Species Percentage)	Unidentified Total Positive (Species Percentage)
Northwestern	67	46 (68.65)	6 (8.95)	2 (2.98)	13 (19.40)	70	53 (75.71)	4 (5.71)	2 (2.85)	11 (15.71)
Southwestern	25	11 (44.00)	1 (4.0)	2 (8.00)	11 (44.00)	72	65 (90.22)	2 (2.77)	1 (1.38)	4 (5.55)
North-Central	18	14 (77.77)	0	0	4 (22.22)	26	24 (92.30)	0	0	2 (7.69)
South-Central	13	8 (61.53)	0	0	5 (38.46)	29	20 (68.96)	2 (6.89)	1 (3.44)	6 (20.68)
Eastern	0	0	0	0	0	3	2 (66.66)	0	0	1 (33.33)
Overall (Zone 1)	123	79 (64.22)	7 (5.69)	4 (3.25)	33 (26.82)	200	164 (82.00)	8 (4.00)	4 (2.00)	24 (12.00)

Note: Each trypanosome species in any mixed infection is counted as a separate occurrence.

cases of bovine trypanosomiasis shown in this analysis (Table XII, Figures 4-9) was derived by considering the presence of each trypanosome species as a separate occurrence in any mixed infection. In other words, when two or more trypanosome species were recorded in a head of cattle, each was regarded as a separate occurrence.

In the dry season, a total of six mixed infections was encountered. Three of these infections were composed of T. vivax and T. congolense. Each of the remaining three was a combination of T. vivax and T. brucei. Since each of the six mixed infections was a combination of two trypanosome species, a total of six more occurrences must be added to the actual dry-season positive cases of 117 to bring the total to 123 for the analysis of relative prevalence of various trypanosome species in the dry season.

Similarly, in the rainy season, eight mixed infections were recorded. Six of the eight mixed infections were combinations of two trypanosome species each (four were combinations of T. vivax and T. congolense, and two were combinations of T. vivax and T. brucei). The remaining two were a combination of three trypanosome species each, i.e., T. vivax, T. congolense and T. brucei. Altogether there were 10 additional occurrences, which raised the total of rainy-season positive cases from 190 to 200.

a. Relative Prevalence of T. vivax

Data obtained during the two studies clearly demonstrate the overall predominance of this species of trypanosome in the zone (Table XII, Figures 4-9). The overall prevalence of T. vivax was 64.22 percent and 82.0 percent during the dry and rainy seasons respectively. This predominance can also be seen in each sector. The only exception is the southwestern sector, where the proportion of T. vivax was equal to that of the

unidentified category during the dry-season study. In all other sectors during both seasons, T. vivax was outstandingly predominant and widely distributed in the study area (Figures 6-9).

b. Relative Prevalence of T. congolense

The overall relative prevalence of T. congolense recorded for the zone was 5.69 percent and 4.0 percent during the dry- and rainy-season investigations respectively, thus placing this trypanosome second in importance among identified species.

A similar trend can be noticed on a sector basis with only one exception (Figures 4-5). In the southwestern sector, during the dry season, T. congolense was recorded to be 4.0 percent as against an 8.0 percent incidence of T. brucei.

The distribution of this species of trypanosome was restricted in the zone (Figures 6-9). As can be seen from the maps, T. congolense was only recorded in the villages Kalifabougou, Komi-Komi, Farabana, Faraba, Kamale, and Bankoumana in the northwestern sector (Figure 6). In the southwestern sector it was recorded in villages Tyele, Digato, and Bala only (Figure 7). No T. congolense was recorded in the north-central sector (Figure 8). In the south-central sector, occurrence of this species of trypanosome was recorded only at Mantola village (Figure 9). T. congolense was not recorded in the eastern sector of the zone.

c. Relative Prevalence of T. brucei

In the data obtained during both seasonal studies, T. brucei ranked third in occurrence among the identified trypanosome species. Its overall relative prevalence for the zone was 3.25 percent and 2.0 percent for the dry and rainy seasons respectively. A similar

trend was noticed even on a sector basis with only one exception. As mentioned above, the exception occurred in the dry season in the southwestern sector where T. brucei ranked second in importance among three identified trypanosome species (Table XII).

T. brucei also showed a restricted distribution in the zone (Figures 6-9). It was recorded only in villages Noumoubougou, Faraba and Dyeliba in the northwestern sector (Figure 6), in the villages Manankoroni, Digato and Tyele in the southwestern sector (Figure 7), and in the village Mantola in the south-central sector of the zone. The north-central and eastern sectors did not reveal the presence of T. brucei.

d. Relative Prevalence of the Unidentified Category

Overall relative prevalence of the unidentified category of trypanosomes in the zone ranked second among the whole group. Its overall relative prevalence in the zone was 26.82 per cent and 12.0 per cent for the dry and rainy seasons respectively. The same trend was seen on an individual sector basis during both seasons. The only exception was the one noticed in the southwestern sector during the dry-season investigation. Here, T. vivax and an unidentified category were found in equal proportion (Table XII).

3. Cattle Morbidity and Mortality due to Animal Trypanosomiasis

Under the existing circumstances it is very difficult to collect reliable data on cattle mortality due to bovine trypanosomiasis. It is not the only disease encountered in the area. Other important diseases include contagious Bovine Pleuropneumonia, Haemorrhagic Septicemia, Black-Quarters, Anthrax, Streptothricosis, and various tick-borne diseases, to mention only a few. The cause of death is rarely established.

Mortality and cattle population figures given by cattle breeders are hardly reliable or meaningful. Reliable data on this aspect cannot be accumulated until efficient, basic laboratory diagnostic and investigational services are developed and are available to the field staff in the country. Simultaneously, epizootiological assessments of episodes of bovine trypanosomiasis and investigations of as many outbreaks of the disease as possible should be carried out in order to build up the data. The most meaningful data can be collected on site during an outbreak of the disease. Accumulation of these data is a long-term, continuous process and cannot be accomplished by merely visiting the field occasionally or even by virtue of routine sampling campaigns.

Despite the efforts made during the course of these studies, concrete data on cattle mortality due to trypanosomiasis could not be obtained. Mortality figures supplied by the owners were erratic and unreliable in most cases. These figures cannot be used to work out the overall impact of the disease in the zone. An impression of the magnitude of the harm done by animal trypanosomiasis in cattle can, however, be gained from observations made during the investigations in both seasons.

In general, the disease encountered during the dry season was of a mild, chronic nature, excluding the outbreak of the disease at Farabana. A general loss of condition and unthriftiness was invariably noticed in infected herds. Many cattle with enlarged superficial lymph glands were observed, especially in the northwestern and southwestern sectors. Peripheral parasitemias encountered during the dry season were generally of low degree. In many cases only a few parasites could be detected in thick blood smears and lymph node biopsy smears.

The disease appeared to be much more pronounced in the rainy than in the dry season. Heavy and active peripheral parasitemias were frequently observed and clinically sick animals were often encountered in the northwestern and southwestern sectors and in other endemic foci of the disease in the north-central and south-central sectors.

Some of the episodes of bovine trypanosomiasis encountered during the study are recorded below.

4. Outbreak of Animal Trypanosomiasis at Various Villages

a. Farabana

This village is situated about 25 km southwest of Bamako in the northwestern sector of the zone. It is located near the southeastern edge of the Forêt Classée des Monts Mandingues on the northern bank of the Niger River (Figures 3 and 6). A severe outbreak of animal trypanosomiasis was recorded here in October 1979. Two herds, each consisting of about 140 cattle of Ndama, Zebu and Mere breeds, were affected. A total of 40 animals were lost within ten days of the beginning of the outbreak. In other words, mortality was 14.28 percent. Seven animals aborted in one, and three in the other herd, yielding a 3.57 percent rate of abortions. Milk yield was reduced and both herds were in a state of poor health. Nearly 90 percent of the animals had markedly swollen superficial lymph glands and were weakened and emaciated. The disease was confirmed in 48.0 percent of the cattle. *T. vivax* and *T. congolense* were found to be responsible. The disease was also confirmed in a dead animal during post mortem examination. Laboratory confirmation was done by finding degenerating trypanosomes such as those described as "trypanosome en boule" by Laveran (1911) and Fiennes (1952a), or cryptic trypanosomes in brain capillaries. Mortality was dramatically halted by mass

inoculation with Berenil (Diminazene aceturate, Farbwerke Hoechst, A.G.).

b. Faraba

This village is located within the Forêt Classée des Monts Mandingues about 5 km west of Farabana. A situation worse than Farabana was expected here during the rainy season. The total livestock population of this village was 36 cattle, five sheep, five goats and four donkeys. All of them were sampled. Among these, seven cattle, one sheep, one goat and one donkey were infected. *T. vivax*, *T. congolense* and *T. brucei* were found to be responsible for the disease. One of the cattle carried all three species of trypanosomes. A total of ten cattle were reported to have died, bringing the mortality to 21.73 percent. The herd was inoculated with Berenil after sampling.

c. Kamale

This village is located a few km southwest of Faraba in the northwestern sector. During the rainy season, a total of 12 cases out of 50 cattle examined were confirmed. Three of the cases involved heavy and active parasitemia, two of which were clinically sick. Five head of cattle were reported to have died recently showing 9.09 percent mortality.

d. Manankoroni

This village is located in the southwestern sector between the south bank of the Niger River and the Forêt Domaniale Classée de la Faya. A very heavy incidence of the disease was recorded here during the rainy season. Seventeen of the 50 cattle examined showed peripheral parasitemia. In six of the positive cases, parasitemias were active, and three were clinically sick. No mortality as yet had occurred. Low incidence of the disease was recorded here in the dry season.

c. Tyele

This village is also situated in the southwestern sector, a few km south of the Forêt Domaniale Classée de la Faya. High incidence of the disease was encountered even during dry season, when five of the 50 head of cattle examined were found to have varying degrees of peripheral parasitemia. Three of these animals showed dividing trypanosomes but parasitemia was low and there were no apparent clinical symptoms. A much higher disease incidence was seen during the rainy season, when 16 of the 50 head of cattle were positive, with six showing active and heavy peripheral parasitemia. One of the animals with active parasitemia was clinically sick. No deaths had as yet occurred.

f. Saï

This village is located in the north-central sector on the north bank of the Niger River. This village herd was found to be badly infected during the rainy season investigation. Among 25 head of cattle sampled, seven were positive, one of which was sick clinically. Heavy and active infection was confirmed in this animal later in the laboratory. No death, however, was reported.

It was interesting to note that all 20 sheep and two goats sampled from the village were negative, despite heavy incidence of the disease among cattle.

All 21 cattle examined during the dry season from this village were negative.

g. Niamina

Niamina is another important village encountered in the north-central sector. The village is located between the Forêt Classée de Niamina and the north bank of the Niger River. The village was negative in the dry season, but five of 20 cattle examined during the

rainy-season study were positive. All the positive cattle showed active parasitemia, and two exhibited more than 100 parasites per microscopic field. Three of the positive animals were clinically sick. This situation was encountered despite the fact that Berenil had been administered to these cattle by the owners only a month before the sampling was done. No mortality had yet occurred, although a number of animals appeared on the verge of death.

D. Trypanosomiasis in Other Livestock

1. Sheep

A total of 506 sheep were examined during the dry and 185 in the rainy-season study. Among them, 0.39 percent and 1.62 percent were found infected in the dry and rainy seasons respectively. *T. vivax* was the only trypanosome species found responsible for infection in these animals. As can be seen from Table XIII, the positive sheep were only found in the northwestern sector during the dry season. Positive cases were, however, detected from three sectors during the rainy-season study. The sheep found to be infected with trypanosomes did not show any significant ill health which could be related to the presence of these organisms.

2. Goats

None of the 432 goats examined during the dry season showed the presence of any trypanosomes. In contrast one of the 84 goats examined during the rainy season exhibited peripheral parasitemia with *T. vivax*. As in the sheep, no clinical signs were observed in this animal. Incidence is recorded in Table XIII.

3. Donkeys

A total of 145 donkeys was examined during the dry and 15 in the rainy season. Among them 1.37 percent

TABLE XIII

TRYPANOSOMIASIS IN OTHER LIVESTOCK

Sector	Dry Season Survey				Rainy Season Survey			
	Sheep	Goats	Donkeys	Horses	Sheep	Goats	Donkeys	Horses
	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)	Total Positive/ Total Examined (Percent Positive)
Northwestern	2/69 (2.89)	0/86	1/26 (3.84)	0/4	1/34 (2.94)	1/20	1/7 (14.28)	0
Southwestern	0/52	0/24	0/19	0	1/35 (2.85)	0/30	0/8	0
North-Central	0/111	0/107	0/40	0/4	1/102 (0.98)	0/34	0	0
South-Central	0/179	0/115	1/36 (2.77)	0/2	0/14	0	0	0
Eastern	0/95	0/100	0/24	0/8	0	0	0	0
Overall (Zone 1)	2/506 (0.39)	0/432	2/145 (1.37)	0/18	3/185 (1.62)	1/84 (1.19)	1/15 (6.67)	0

and 6.66 percent were found infected in the dry and rainy seasons respectively (Table XIII). The distribution of two positive cases during the dry season was in the northwestern and south-central sectors. The animal in the northwestern sector was found to be infected with T. vivax, while the one from the south-central sector was carrying T. brucei. During the rainy season, one of the 15 donkeys examined in the northwestern sector was found to be infected with T. vivax. No significant clinical signs were observed in any of the positive cases.

4. Horses

A total of 18 horses was examined in the dry season. None of them was found to be infected (Table XIII).

E. Tick-Borne Diseases

Babesia bigemina, B. bovis, Anaplasma marginale, Theileria mutans, and Borrelia spp. were frequently encountered, especially in the northwestern and southwestern sectors. The frequency of the presence of these organisms appeared to have increased in the rainy compared with the dry season. Since the time was limited, no attempt was made to study their incidence critically.

CHAPTER IV

DISCUSSION

CHAPTER 4
DISCUSSION

In considering the data obtained on the incidence of trypanosomiasis, it is important to bear in mind the limitations of the detection methods used, the widespread and indiscriminate use of trypanocides by cattle breeders, and the presence of relatively trypano-tolerant breeds of cattle, especially in the endemic areas of the zone.

A. Limited Detection Methods

The first factor to be considered is the limitation of the detection methods used. Ever since the demonstration of *Trypanosoma evansi* as the cause of surra in camels and horses (Evans, 1880), the detection of trypanosomes in the body of the infected animal still remains the deciding factor in the diagnosis of infection and in the morphological identification of the species causing the infection (Molyneux, 1975). Although a variety of protozoological diagnostic methods, from the simple to the sophisticated, are available for the field diagnosis of trypanosomiasis, their use is dependent upon conditions and resources available (Lanham, 1977). Six methods, i.e., thick blood smears, lymph smears, hematocrit centrifuge technique, rodent inoculation, culture, and the DEAE-cellulose column separation technique, were suggested for the diagnosis of trypanosomiasis in general. Among these, the first four methods were recommended for extensive surveys while the last two were recommended for small surveys.

Two of the first four methods above, plus examination of thin blood smears, were undertaken in the present investigation, mainly because of the limited resources available and at the investigators' disposal, and also because of the difficult field conditions. Other technical considerations were as follows:

- Thick blood smears were included because 120 times more blood could be scanned in a thick blood smear in which the red blood corpuscles were hemolyzed than in a thin blood smear (Fiennes, 1952b). In general this method is considered useful in the diagnosis of infections in animals caused by T. vivax and T. congolense (Killick-Kendrick and Godfrey, 1963; Robson and Ashkar, 1972).

- Thin blood smears were regarded as obligatory since trypanosomes in thick blood smears are distorted during the process of de-hemoglobinization and staining, and are hence unidentifiable. Exhaustive search of thin blood smears is necessary to find sufficient trypanosomes for the identification of species (Killick-Kendrick, 1968).

- Lymph node biopsy smears were included since more infections in cattle, especially T. vivax, can be detected with this method (Montgomery and Kinghorn, 1909; Robson and Ashkar, 1972).

- A combination of the three above methods was adopted, so that one would prove complementary to the others, especially examination of lymph versus blood. It was considered particularly important in order to overcome the limited diagnostic value of each of these methods when used independently.

In this study, lymph node biopsy smears were found to be the most efficient of the three methods used. Examination of lymph appeared particularly helpful during the dry-season study, when a large proportion of the infections encountered were with low-grade peripheral parasitemia. Most of the infections encountered during the dry season were probably chronic in nature. This was perhaps the reason why lymph node biopsy smears were relatively more efficient in the dry season compared with the rainy-season investigation. As can be noted from the results, there were only three instances during the dry season where thick blood smears were positive but where the corresponding lymph node biopsy smears were negative.

In contrast, most infections during the rainy season were much more virulent, with heavy and active parasite-

mias. Probably, most of the infections encountered were fresh infections, which may explain the improved efficiency of thin and thick blood smears during the rainy season compared with their efficiency during the dry-season investigation. Higher frequency of heavier parasitemias during the rainy season also explains the parallel efficiency of thin and thick blood smears as experienced in the north-central and eastern sectors during the rainy season. These fresh infections were probably responsible for reducing slightly the overall efficiency of lymph node biopsy smears in the rainy as compared with the dry season.

This factor also seems to be at least partly responsible for the relative inferiority of the lymph node biopsy smears noticed in the south-central sector during the rainy season. It may be that a large proportion of the infections encountered here were fresh infections which could not be detected by lymph node biopsy smears. This belief is further supported by the fact that the major cause of this variation was the results obtained from a nomadic herd examined at Mantola village in the sector. Six of the 50 cattle examined in this herd were positive. In five of the six, positive cattle lymph node biopsy smears were negative. It is likely that most infections in this herd were fresh infections picked up during transhumance and could not be detected by lymph node biopsy smears.

While the overall diagnostic value of lymph node biopsy smears was generally superior in terms of the number of positive cases detected, the number of parasites per microscopic field was usually much lower than in thick blood smears. In some cases, only one parasite could be detected among 50 fields examined in a lymph node biopsy smear, while the corresponding thick blood smear showed 10

parasites per microscopic field. This was particularly evident if the lymph node biopsy smear was not contaminated with blood. This variation did not seem to be related exclusively to the thinness or thickness of lymph node biopsy smears.

B. Indiscriminate Use of Trypanocides

The second factor to consider is the extensive and indiscriminate use of trypanocidal drugs in the area. A head of cattle showing any sign of ill health usually gets a shot of Berenil, regardless of the disease the animal may actually be suffering from. It is a very common practice and can easily mask the real incidence of the disease.

C. Trypano-tolerant Breeds of Cattle

The third important factor influencing the incidence of trypanosomiasis is the presence of relatively trypano-tolerant cattle in the area. Herds were mainly composed of Ndama and Mere cattle in the northwestern and south-western sectors. The composition changed gradually in northern and eastern areas, where more and more Zebu composed the herds. This trend is interesting and shows the awareness of the breeders of the presence of greater disease risk, especially in the northwestern and southwestern sectors of the zone as compared with eastern areas. This risk can be avoided, at least to some extent, by keeping relatively trypano-tolerant breeds of cattle in the disease-prone sectors.

D. Disease Incidence in the Zone

Despite the limited diagnostic values of the methods exploited, extensive and indiscriminate use of trypanocidal drugs and the presence of relatively trypano-tolerant cattle in the area, a significant incidence of the disease was recorded in the zone, with a

marked variation in its occurrence between the two seasons. The disease appeared to be of a mild and chronic nature during the dry season, with generally fewer cases in each village as compared w th the rainy season. In the rainy season investigation, several sick animals with heavy and active parasitemia were encountered. The number of positive cases recorded in each village was generally higher, showing a significant increase in the incidence of the disease in the rainy as compared with the dry season. Camus et al. (1979), working in the Ivory Coast, reported that the number of positive trypanosomiasis cases in an experimental herd of cattle increased in the rainy season compared with the dry season.

The delineation and extent of the disease in the northwestern and southwestern sectors of the zone generally coincides with the distribution of the vector in the area. Three species of the fly, viz. Glossina palpalis, G. morsitans, and G. tachinoides were recorded, with varying degrees of infestation. G. palpalis was found to be widely distributed in most areas (Okiwelu et al., 1978, 1979).

The picture of the disease obtained in the north-central and south-central sectors seems to be related to the presence of G. palpalis in the area. During recent studies, G. palpalis was caught in large numbers all along the Niger River from east of Bamako to Samaflala, near Segou, in the west. In addition, a few specimens of G. tachinoides were caught between Kamini in the west and Sai in the east along the Niger River. No G. morsitans was caught during the dry season (S. Maïga, personal communication).

These results suggest that G. palpalis plays an important role in transmission of bovine trypanosomiasis in these areas. Contact between riverine tsetse and

livestock may sometimes be close and even prolonged, and although these species are less efficient vectors, they are probably responsible for a significant proportion of the trypanosomiasis occurring in livestock in West Africa (Maclennan, 1970). Intensive study of the situation of the vector species and related factors during the rainy season is, however, important in order to determine the precise role of G. palpalis in the transmission of bovine trypanosomiasis in the area.

Some of the disease in the north-central, south-central and eastern sectors appears to be an infection carried by nomadic cattle. It was not uncommon to find nomadic herds of cattle in these sectors. Nomadic herds were found more widely infected than sedentary herds during the dry season, although the reverse was generally the situation in the rainy season, with the exception of the north-central sector, where again the nomadic herds were found more commonly infected (Table IX). They can be held responsible, at least partly, for the spread of the disease, especially in the north-central and south-central sectors. It may also be true for the eastern sector, but no evidence to support this hypothesis was found.

E. Differences in Susceptibility among Various Breeds and Age Groups of Cattle

Data obtained during the study of the incidence of bovine trypanosomiasis revealed important information on the susceptibility of various breeds and differences in susceptibility between two age groups of cattle.

Chandler (1952, 1958) observed that pure Ndama herds in tsetse-infected areas of West and Central Africa rarely developed demonstrable peripheral parasitemia or the disease. On the other hand, Ndama-Zebu crosses and Zebu developed heavy parasitemia and disease with fatal results. It was postulated that once Ndama have been

infected and have recovered, subsequent infections result in low parasitemia and little disease.

It is now an accepted epizootiological fact that many breeds of cattle in West Africa can withstand the challenge of trypanosomiasis better than others. This phenomenon is known as trypano-tolerance, although in immunological terms this is a misnomer in that trypano-tolerant animals do, in fact, respond immunologically to the trypanosome (Murray and Morrison, 1979). During the present studies, Zebu were observed to be most susceptible to animal trypanosomiasis, when the data was examined on a sector basis, with only a few minor exceptions. The average trend for each season, however, completely changed, and Zebu turned out to be the least infected. This distortion was brought about by the fact that enormous numbers of Zebu were sampled in relatively low challenge areas in both seasons. More work on this score is needed to clarify the situation.

Calves have been shown by various workers (Schilling *et al.*, 1934, Bevan, 1936, and Hornby, 1941) to be comparatively resistant to animal trypanosomiasis. These studies clearly demonstrate that calves are comparatively more resistant to animal trypanosomiasis than adult cattle in the Niger Valley (Table XI).

F. Prevalence of Various Trypansome Species

While knowledge of the disease incidence is imperative, information on the relative prevalence of various trypanosome species is also important in formulating specific chemotherapeutic and chemoprophylactic control measures.

Hornby (1952), with his tremendous experience with trypanosomiasis, believed that *T. congolense* constituted the most important form of animal trypanosomiasis, stating,

> This is the most important animal trypanosomiasis in Africa. There is no tsetse belt where it does not occur and every kind of domestic mammal is suceptible to grievous infection. This ubiquity gives a sameness to the syndrome of whatever animal is affected; only in pigs is there a resistance to infection markedly higher than that shown by other species.

Despite the general importance of this species of trypanosome, marked variations exist between the relative importance of T. congolense and T. vivax in various parts of the continent as is evident from the following.

Macfie (1913), working in northern Nigeria, reported that T. vivax was the most common cause of trypanosomiasis in Fulani and dwarf cattle, sheep, goats, horses, donkeys and dogs. Out of 86 assorted such animals, all of which showed trypanosomes in their blood, 53 were infected with T. vivax alone.

Carmichael (1948) believed that T. vivax did not cause severe disease in dwarf cattle in West Africa provided the cattle were kept under good conditions of husbandry and were properly nourished.

Unsworth (1953) reported that T. vivax was responsible for a 100 percent mortality rate when groups of Zebu cattle were grazed continuously in tsetse-infested areas, but that mortality in native-owned Zebu cattle was not so high because the animals were rarely grazed regularly in tsetse-infested areas, but were moved periodically. T. vivax was detected in 39.0 percent of the blood smears of 965 Zebu cattle from various parts of Nigeria; 26.0 percent of the infections were caused by T. congolense and 0.4 percent by T. brucei, with 4.0 percent of the cases being mixed infections. In an experiment where 123 head of Zebu cattle were exposed to natural infection in seven localities of Nigeria, 82.0 percent of the resultant infections were caused by T. vivax, 4.0 percent by T. congolense and 14.0 percent by T. vivax and T. congolense mixed.

Godfrey and Killick-Kendrick (1961), on the other hand, reported a low relative incidence of T. vivax and a high relative incidence of T. congolense in cattle of the Donga Valley in the Benue Province of Nigeria. Later Godfrey et al. (1965), studying infection rates among migrating cattle, reported an incidence of 30 to 60 percent with T. vivax, T. congolense and T. brucei, among which T. vivax was the dominant species.

Awan and Sawchuk (1976), reporting the incidence of bovine trypanosomiasis in the Southern Province of Zambia, showed that T. congolense represented the large majority of cases, averaging 72.3 percent of the infection., while T. vivax accounted for 18.6 percent and other species only 9.1 percent.

In the present studies, T. vivax was found to be predominant in the study area during both seasons. The only exception noted was in the southwestern sector, where the proportion of T. vivax was found to be equal to that of the unidentified category during the dry-season study. This fact was the result of the choice of criteria adopted for the identification of the various trypanosome species. T. congolense was found to be generally second in importance, followed by T. brucei. The real incidence of T. brucei, however, may be much higher than detected by the methods used in this study. Detection of T. brucei by blood slides is often difficult and a higher incidence of this species may be revealed if rodent inoculation methods are used (Godfrey and Killick-Kendrick, 1961; Baker, 1967; Dillmann and Awan, 1972).

Unidentified infections constituted a large proportion and ranked second in importance among the whole group. It is to be recalled that the identification of trypanosome species was always based on finding trypanosomes in thin blood smears. If a thin blood smear was negative but the

corresponding thick blood smear or lymph node biopsy smear or both were positive, the trypanosomes thus found were classed as unidentified. Based on this criterion, while keeping in mind the limited relative value of thin blood smears, a high proportion of unidentified trypanosomes were recorded, although most of them were probably T. vivax. Application of this criterion was responsible for the generally high proportion of the unidentified category of trypanosomes.

G. Trypanosomiasis in Other Livestock

Although sheep and goats, especially the dwarf type, are generally considered relatively resistant to trypanosomiasis, records of the disease incidence in them are available. Kramer (1966) reported an incidence of 13.8 percent with either T. congolense or T. vivax in goats in eastern Nigeria. Mornet (1954) considered that sheep and goats constituted about 40 percent of all the animals infected with T. congolense but believed that the incidence could be higher, as small ruminants were rarely investigated in trypanosomiasis surveys.

During the course of these studies, the number of sheep and goats found infected wtih pathogenic trypanosomes was small. In some villages, despite heavy incidence of animal trypanosomiasis in cattle, sheep and goats were found to be negative. A high incidence of trypanosome infections was detected in donkeys during the rainy season, but the small size of the sample reduces the significance. All horses examined were negative, although the sample size was again too small to be considered significant.

CHAPTER V

RECOMMENDATIONS

CHAPTER 5

RECOMMENDATIONS

A. Bovine Trypanosomiasis Sample Survey

The present investigation has provided insight into some of the important aspects of animal trypanosomiasis in the zone. These intensive studies on the incidence and distribution of bovine trypanosomiasis should now be extended, by spot or sample survey in the rest of the southern, western and some adjoining peripheral areas, to all fly-infested zones of the Republic of Mali. The total area to be covered should be divided on the basis of Veterinary Arrondissements, selecting for investigations a limited number of villages in each arrondissement. A detailed schedule should be drawn up for each arrondissement and advance copies of the program should be circulated to all concerned officers in the field.

The collection of samples should be done by the LCV (Central Veterinary Laboratory) collecting team(s) with the cooperation of on-the-spot field officers and their staffs. Collection work should commence as soon as the facilites are available for the accomplishment of at least half of the target. The work can be initiated at any time of the year and should continue throughout the year(s) to completion, regardless of season.

The entire schedule of work can be divided and assigned to various collecting teams, depending on the number of teams available. The minimum number of field teams recommended is two.

Sample survey data collected by the teams when coupled with the information already obtained from Zone 1 would provide enough data to map out the exact position of animal trypanosomiasis in the country.

This information is vital in planning any meaningful disease control and in further livestock development in potentially the richest areas of the country.

Facilities required to conduct this program are shown in Appendix I. These facilities are in addition to those already available. The techniques to be deployed in the planned program are considered. The collection of two buffy coat thick smears after hematocrit centrifugation of peripheral blood and two thin blood smears from each animal should be required in the proposed survey.

Consumable items are estimated on the basis of two field teams, each working for a period of one year, sampling about 20,000 head of cattle. Team composition is recommended on the basis of experience in Zone 1. It should be composed of an engineer or senior technician with two capturers and a driver. There should be a possibility of hiring extra labor on the spot, if and when necessary.

Another very important aspect is the strengthening of the existing laboratory staff. It is strongly recommended that two competent, senior technical officers should be appointed to the laboratory to handle the influx of thousands of smears from the field.

B. Control by Chemotherapy and Chemoprophylaxis

Unless the real situation of the disease is known for all the infested areas, meaningful trypanocidal drug policy for the entire country cannot be formulated, although there is an urgent need to rationalize the usage of trypanocidal drugs in the country. It is imperative to devise ways and means to stop the indiscriminate use of trypanocidal drugs immediately by enacting legislation prohibiting the use of trypanocidal drugs by non-veterinarians. This is absolutely important to prevent the development of drug-resistant strains of trypanosomes.

In any drug regimen it is highly desirable that drugs used for either therapeutic or prophylactic purposes should always belong to two different chemical groups. Doses and intervals between dosings recommended should be strictly controlled and adhered to, until a yearly review of the regimen is made.

The following alternative drug regimens are suggested for Zone 1. It is to be realized that the regimens suggested below are strictly related to the present disease position of the area. These would change with the change in disease situation, which may be brought about by a vector control program. It is emphasized that the implementation of any of the regimens suggested below does not mean that the disease can be brought under control forever by their prolonged usage. Vector control remains the only long-term solution to the problem.

1. Regimen No. 1

Ideally four treatments of Trypanidium (Isometamidium chloride, S.P.E.C.I.A), each at the rate of 0.5 mg/kg, should be administered per year in endemic areas, including permanent foci of the disease. There should be a three-month interval between each dosing. Any animal requiring treatment in between dosings should be treated with Berenil at the rate of 3.5 mg/kg. Approximately 10-15 percent of cattle should be sampled routinely for thick blood smears prior to dosing with Trypanidium in order to monitor its use and to guard against the possibility of development of drug resistance. In areas where the disease is sporadic, surveillance only should suffice and only sick animals should be treated with Berenil at the rate of 3.5 mg/kg. The regimen should be reviewed for effectiveness after one year of implementation.

2. Regimen No. 2

There is no doubt that regimen number 1 is expensive, but the risk of the development of drug resistance is very low, particularly if the regimen is strictly controlled. Alternatively, in order to reduce cost, the following regimen is suggested.

Two prophylactic treatments with Trypanidium to be administered at three-month intervals at the rate of 0.5 mg/kg between July and December of each year in endemic areas, including permanent foci of the disease. During the period of low challenge, disease surveillance at regular intervals should be instituted. This could be accomplished by taking thick blood smears from 10-15 percent of the cattle, including suspicious cases. Treatments with Berenil at the rate of 3.5 mg/kg should be provided to animals showing infections. In sporadic incidence areas the standard treatment with Berenil only should be carried out.

The regimen should be reviewed after one year of implementation.

C. Establishment of Trypanosomiasis Research and Diagnosis Unit (TRDU)

One of the basic requirements for the investigation of any disease problem is the availability of a properly equipped and staffed laboratory. The degree of competence required for thorough trypanosomiasis research and investigation, in both the equipment and expertise, is much higher than for many other diseases because of the complexities of the disease. Some of these complexities are the large range of animal species susceptible to trypanosomiasis, the multiplicity of strains and antigenes of trypanosomes, antigenic variation, different pathogenicities of individual species, including, in different locations and hosts, rapid development of drug

resistance and intricate epizootiology of the disease. A reasonable degree of local knowledge of various parameters is essential to the development and implementation of long-term disease control strategy. To achieve this objective the establishment of a Trypanosomiasis Research and Diagnosis Unit (TRDU) in the country is strongly recommended. A model of such a unit is provided below.

D. Terms of Reference of TRDU

1. Intensive survey of the disease in a selected area (completed).

2. Sample survey in other areas of the country as per recommendation A.

Numbers 1 and 2 will permit the development of a comprehensive disease distribution map of the country, providing baseline information for all future strategies.

3. Epizootiological investigations, including assessments of as many new episodes of animal trypanosomiasis as possible.

4. Pre-control and post-control assessment of animal trypanosomiasis in a given area.

5. Evaluation of chemotherapeutic and chemoprophylactic compounds and formulation of suitable drug regimen(s).

6. Monitoring of various drug regimens and mounting of drug resistance investigations wherever and whenever necessary.

7. Development and exploitation of various protozoological, immunological, and serological methods of diagnosis.

8. Isolation, cryostabilization and characterization of trypanosome species and strains, study of their virulence, pathogenicity, drug sensitivity, etc.

9. Close liaison between the TRDU and the Service de l'élevage in order to provide specific diagnostic, investigational and consulting services.

E. Special and Physical Facilities

It is stressed that the development of a TRDU is a continuous process requiring long-term development of staff and facilities. The following specialized facilities are needed:

1. Cryostabilization of Trypanosomes

   This is an essential component of any trypanosomal research program, particularly needed for items 3-8 listed under the terms of reference of TRDU.

2. Protoecology Laboratory Block

   The existing building is inadequate to cater for the full needs of the Unit. Proposed TRDU should have the following accommodations.

   a. Main protozoology laboratory

   b. Protozoologist's office *cum* laboratory

   c. Veterinary Investigation Officer's office *cum* laboratory

   d. Engineer's/Technician's office/laboratory

   e. Washing and sterilization facilities

   f. Storerooms

   g. Archives and secretary's office

   h. Small Animal Resources Unit. This support service will serve primarily as a source of supply of rats and mice needed for experimental purposes. It should have an additional small laboratory for conducting inoculations and which also should serve as the base for the collection of infective material from experimentally inoculated rodents.

   i. Isolation block. This is an extremely important cell and an essential component for a good standard veterinary protozoology setup, particularly needed for trypanosomiasis research and research in tick-borne disease. The block should be able to house

both large and small livestock on a limited scale. It should be an independent and self-sufficient unit as far as storage, washing and disposal facilities are concerned. It should also have a small laboratory for handling infective material. A special feature of this facility should be its complete isolation from the rest of the laboratory and other surroundings. Other features should include a double door entrance and exit, dip wash gutters around calf and sheep pens, fly proofing, special drainage and incineration facilities for the proper disposal for infected material.

F. Staff

Minimum staff recommended for the TRDU is as follows:

Veterinary Protozoologist:	1
Veterinary Investigation Officer or Epizootiologist	1
Technicians (various categories)	8
Laboratory assistants	6
Steno-typist	1
Drivers	2

A list of equipment, chemicals and other materials required for the TDRU is provided in Appendix II.

G. Human Trypanosomiasis

It is recommended that a close liaison between the Trypanosomiasis Research and Diagnosis Unit and the Department of Health Services be maintained to ensure the exchange of research and investigation data into the overall trypanosomiasis situation, both animal and human.

H. Staff Development and Training

Efforts should be made to retain the existing staff who have had practical training during the course of this study. Their experience is valuable and should be further utilized in order to build staff resources. Training of a specialized veterinarian to the level of Veterinary Protozoologist should be anticipated. The TRDU is a

long-term program and is recommended to initiate it as soon as possible. Training of the Engineer Mr. S. Bouaré to the level of veterinarian is also strongly recommended, particularly in view of his experience in animal trypanosomiasis in Mali.

CHAPTER VI

SUMMARY

CHAPTER 6

SUMMARY

Thin and thick blood smears and lymph node biopsy smears were used in both seasons to survey the incidence of bovine trypanosomiasis in the zone. Thin and thick blood smears only were used in other livestock to detect trypanosome infections. Lymph node biopsy smears were generally found to be most efficient in detection of positive cases of bovine trypanosomiasis. Thick blood smears ranked second and thin blood smears were least effective but had to be used for morphological identification of trypanosome species.

Two surveys were carried out to study the incidence of bovine trypanosomiasis and seasonal variation in its occurrence. In the dry-season survey, a total of 117 trypanosomiasis cases were detected out of 3758 cattle sampled, showing a 3.11 percent incidence of the disease in the zone. During the rainy-season survey, a total of 190 positive cases were recorded among 3542 cattle, bringing the rainy season incidence of the disease to 5.36 percent. A significant increase of 2.25 per cent in the disease incidence was recorded during the rainy season investigation over the dry-season disease incidence.

Trypanosomiasis in cattle was generally found to be mild and of a chronic nature during the dry season, with generally fewer cases detected per village. In contrast, the disease appeared to be virulent in the rainy season, when several cases with heavy and active parasitemia were recorded. Many clinically sick cattle were seen in the rainy season, especially in endemic areas. The number of positive cases detected per village was usually higher in the rainy season.

Bovine trypanosomiasis seemed to be endemic in the northwestern and south-central sectors. Disease was detected in a significant number of animals in most villages examined, during both seasons. A higher incidence of the disease was observed in the southwest, with greater disease precipitation in villages near the forest reserves and near the river banks.

In the north-central and south-central sectors, the distribution of the disease was found to be rather patchy, with higher numbers of cases recorded around forest reserves. Small permanent foci of the disease were seen along the Niger River and its main tributaries. Some of the disease present in the two sectors appeared to occur sporadically.

In the eastern sector, permanent foci of the disease seemed to be absent, and the only incidence recorded during the rainy season appeared sporadic.

The distribution of the disease appeared to correspond to the distribution of its vector. G. palpalis seemed to play an important role in the epizooticlogy of animal trypanosomiasis in the zone.

Transhumance seemed to be responsible, at least partly, for the spread of the disease in the north-central and south-central sectors. It may also be true for the eastern sector, but no evidence was recorded to support this possibility.

Zebu were found to be generally most susceptible to animal trypanosomiasis in most sectors, during both seasons. The order of susceptibility changed in seasonal average figures when Mere showed maximum susceptibility, followed by Ndama and Zebu. This distortion was brought about by the fact that large numbers of Zebu cattle were sampled in the relatively disease-free areas while only a few of them were available for sampling in endemic areas.

Two age groups were sampled during both studies. Cattle below six months of age were classed as calves, while those three years and above were classed as adults. A clear-cut difference in susceptibility of the two age groups was obtained during both the seasons. Calves were found to be more resistant than adults.

A total of six and eight mixed infections were recorded during the dry and rainy season respectively. Three of the dry season infections were a combination of T. vivax and T. congolense, and the three remaining infections were a combination of T. vivax and T. brucei. Six of the eight rainy-season mixed infections were combinations of two trypanosome species each (four were combinations of T. vivax and T. congolense, and two of T. vivax and T. brucei). The remaining two were combinations of three trypanosome species, i.e. T. vivax, T. congolense and T. brucei.

T. vivax was found to be the predominant trypanosome species and was widely distributed throughout the infected areas of the zone during both seasons. T. congolense was found to be second in rank of prevalence among the identified group of trypanosomes. Its distribution was restricted to a few villages in the northwestern, southwestern and south-central sectors only. T. brucei ranked third in occurrence among identified trypanosome species. This species also showed a restricted distribution in the zone. It was only recorded in a few villages in the northwestern, southwestern and south-central sectors.

The unidentified category of trypanosomes ranked second of the entire group. This high occurrence of the unidentified category came about as the result of the choice of criteria adopted for identifying the trypanosomes.

It was not possible to collect precise data on cattle mortality due to animal trypanosomiasis since the cause of death of cattle is rarely established in the area. Mortality and cattle population figures supplied by the breeders are hardly reliable and cannot be used to determine the exact impact of the disease as far as cattle mortality due to animal trypanosomiasis is concerned.

The availability of an efficient, basic laboratory and diagnostic and investigative services to carry out surveys in the country is absolutely essential to build up the requisite data base. In addition, epizootiological assessment of episodes of bovine trypanosomiasis and investigations of as many outbreaks of the disease as possible should be carried out to collect such information.

Occurrence of animal trypanosomiasis in other livestock is recorded below. In sheep, the disease incidence was found to be 0.39 percent and 1.62 percent during the dry and rainy seasons respectively. T. vivax was the only species found to be reponsible for infections. None of the 432 goats examined during the dry season was found to be positive. An infection rate of 1.19 percent was recorded during the rainy-season investigation. T. vivax was the only species found responsible. In donkeys the infection rates of 1.37 percent and 6.66 percent were recorded during dry and rainy seasons respectively. T. vivax and T. brucei were the trypanosomes identified. None of the 18 horses examined was found to be infected.

Among the agents of tick-borne disease, Babesia bigemina, B. bovis, Anaplasma marginale, Theileria mutans and Borrelia were frequently recorded, particularly in the northwestern and southwestern sectors. The frequency of the presence of these micro-organisms appeared to have increased in the rainy season.

The results obtained on various aspects of the incidence of trypanosomiasis are discussed in the light of other people's work. Various recommendations for further work to be carried out, control by chemotherapy and chemoprophylaxis, establishment of a Trypanosomiasis Research and Diagnosis Unit and its module, staff development and training programs are put forward.

APPENDIX I

EQUIPMENT, CHEMICALS AND MATERIALS REQUIRED FOR SAMPLE SURVEY

APPENDIX I

EQUIPMENT, CHEMICALS AND MATERIALS REQUIRED FOR SAMPLE SURVEY

FIELD FACILITIES

1.	Hematocrit centrifuges complete with 2 measuring scales	Two
2.	Hematocrit capillary tubes (heparinized)	100 x 1000 pkts
3.	Plasticine trays	50
4.	Generators	Two
5.	Microscope glass slides	200,000
6.	Slide boxes	200
7.	Cooler boxes	8
8.	Cotton wool	10 kg
9.	Enamel trays	10
10.	Hypodermic needles size 16G	20 pkts
11.	Hypodermic needles size 14G	20 pkts
12.	Diamond pencils	6
13.	Felt markers (permanent)	10 pkts
14.	Felt markers (ordinary)	10 pkts
15.	Labels	50 pkts
16.	Cellotape	20 rolls
17.	Wrapping paper (brown)	10 rolls
18.	Cleaning tissues (ordinary)	50 rolls
19.	Plastic bags (assorted)	10 kg
20.	Ethyl alcohol	6 litres
21.	Fly killers (flips)	10
22.	Fly killers (insecticide spray)	50 tins

23. Mosquito repellent cream — 20 jars

24. Full range of camping equipment including one refrigerator for each team

25. Adequate and reliable transport

26. Fuel, lubricants and oils

27. Adequate and regular flow of funds for recurrent expenditures

28. Supply of drugs for the drug box

LABORATORY FACILITIES

1.	Research microscopes (binocular)	Two
2.	Refrigerator with separate deep freezer compartment (double door)	One
3.	Incubator	One
4.	Hot air oven	One
5.	Sterilizer	One
6.	Still	One
7.	pH-meter	One
8.	Water bath	One
9.	Staining dishes	20
10.	Giemsa stain (4-oz bottles)	50
11.	Methyl alcohol	50 litres
12.	Ethyl alcohol	20 litres
13.	Acetone	20 litres
14.	Detergent	20 kg
15.	Buffer concentrate	100 bottles
16.	Graduated pipettes 10 ml	10
17.	Filter paper (sheets)	50
18.	Laboratory tissues (wipes)	100 pkts
19.	Cotton wool	10 kg
20.	Laboratory trays	10
21.	Micro-oil	20 bottles
22.	Xylene	10 litres
23.	Duplicating paper	10 reams
24.	Rubber bands	10 pkts

25. Felt markers (permanent)	10 pkts
26. Felt markers (ordinary)	10 pkts
27. Laboratory labels (assorted)	10 pkts (each size)
28. Disposable gloves	10 pkts
29. Burettes complete with stand, etc.	5
30. Wash bottles	10
31. Wire baskets	10
32. Desiccator	One
33. Laboratory coats (assorted)	10 (each size)

APPENDIX II

EQUIPMENT, CHEMICALS AND MATERIALS REQUIREL FOR THE ESTABLISHMENT OF T.R.D.U.(TRYPANOSOMIASIS RESEARCH AND DIAGNOSIS UNIT)

APPENDIX II

EQUIPMENT, CHEMICALS AND MATERIALS REQUIRED FOR THE ESTABLISHMENT OF TRDU (Trypanosomiasis Research and Diagnosis Unit)

1.	Regular supply of liquid nitrogen	
2.	Liquid nitrogen flasks - complete with canes and canisters	10
3.	Special glass ampules (resistant to -196°C), 1 ml capacity	1000
4.	Special glass ampules (resistant to -196°C), 0.5 ml capacity	1000
5.	Capillary tubes (heparinized)	100 pkts
6.	Capillary tubes (ordinary)	100 pkts
7.	Ampule sealer	1
8.	Refrigerators	2
9.	Deep freezer	1
10.	Centrifuge (bench model)	1
11.	Hematocrit centrifuges complete with kit	2
12.	Water-baths	2
13.	Incubators	2
14.	Hot air oven	1
15.	Microscopes (research binocular)	2
16.	Microscope (fluorescent, phase contrast)	1
17.	Set of millipore filters	1
18.	Autoclave	1
19.	Electric sterilizers (small)	2
20.	pH-meter	1
21.	Distiller	1
22.	Micro-titre sets	2
23.	Analytical balance	1

24.	Prescription balance	1
25.	Hemacytometer sets with extra counting chambers	2
26.	Ceramic ring slides (ADAMS)	24
27.	Disposable blood lancets	50 pkts
28.	Blood taking units	5
29.	Vacutainers (plain)	500
30.	Vacutainers (hep)	500
31.	Vacutainer adaptors	10
32.	Vacutainer sample needles	10 pkts
33.	Vacutainer cork removers	2
34.	Vacutainer serum separation tubes	500
35.	Chill block-storage containers	20
36.	Disposable polyethylene gloves	10 pkts
37.	Disposable vinyl gloves	10 pairs (assorted sizes)
38.	Headgear and visors for full face coverage	2
39.	Stirrer	1
40.	Kolmer racks	10
41.	Test tube supports for water baths	10
42.	Test tube baskets	10
43.	Disposable plastipak syringes, 2, 5, 10 ml	200 each
44.	Disposable needles (various sizes)	2 pkts each
45.	Interval timers	2
46.	Laboratory trays	10
47.	Multi-purpose thermoplastic parafilm	2 rolls
48.	Polyvinyl chloride film	2 rolls
49.	Pasteur pipettes	10 pkts

50. Petri dishes (9 cm)	200
51. Beakers 100 ml (250 ml)	20 each
52. Universal bottles	2,000
53. Bejou bottles	5,000
54. Glass-stopper bottles	100
55. Conical flasks (250 ml)	20
56. Volumetric flasks (1000 ml)	5
57. Centrifuge tubes (conical, graduated 10 ml)	100
58. Centrifuge tubes (round)	100
59. Pipettes (graduated 1 ml, 5 ml)	10 each
60. Rubber teats (ordinary)	100
61. Watman filter paper (round)	10 pkts (each size)
62. Wash bottles	20
63. Mice cages complete with feeders	100
64. Rat cages complete with feeders	20
65. Labo-gas burners	5
66. Labo-gas cartridges	100
67. Pairs of scissors	10 (assorted)
68. Pairs of forceps	10 (assorted)
69. Scalpel blades (assorted sizes)	2 pkts each
70. Scalpel handles (assorted sizes)	2 each
71. Microscope glass slides	50,000
72. Cover-slips (rectangular)	10 02s
73. Cover-slips (round)	10 02s
74. Staining dishes	20
75. Glucose	10 X 500g

76. Sodium citrate	2 X 500g
77. Sodium chloride	10 X 500g
78. Potassium dihydrogen orthophosphate (KH_2PO_4)	500g
79. Di-sodium hydrogen orthophosphate (Na_2HPO_4)	500g
80. Welcome tissue culture (medium 199)	10 bottles (100 ml each)
81. Bovine plasma albumin (crystallized)	50g
82. 2-amino-2 (hydroxy-methyl)-propane 1:3 diol (tris buffer)	5 X 10g
83. Penicillin	5 bottles
84. Diamino-ethane-tetra acetic acid	5 X 10g
85. Difco Bacto Agar	2 X 250g
86. Merthiolate	2 X 100 ml
87. Slide boxes	50

88. Transport: 2 Landrovers
2 Motor bikes

APPENDIX III

REFERENCES

APPENDIX III

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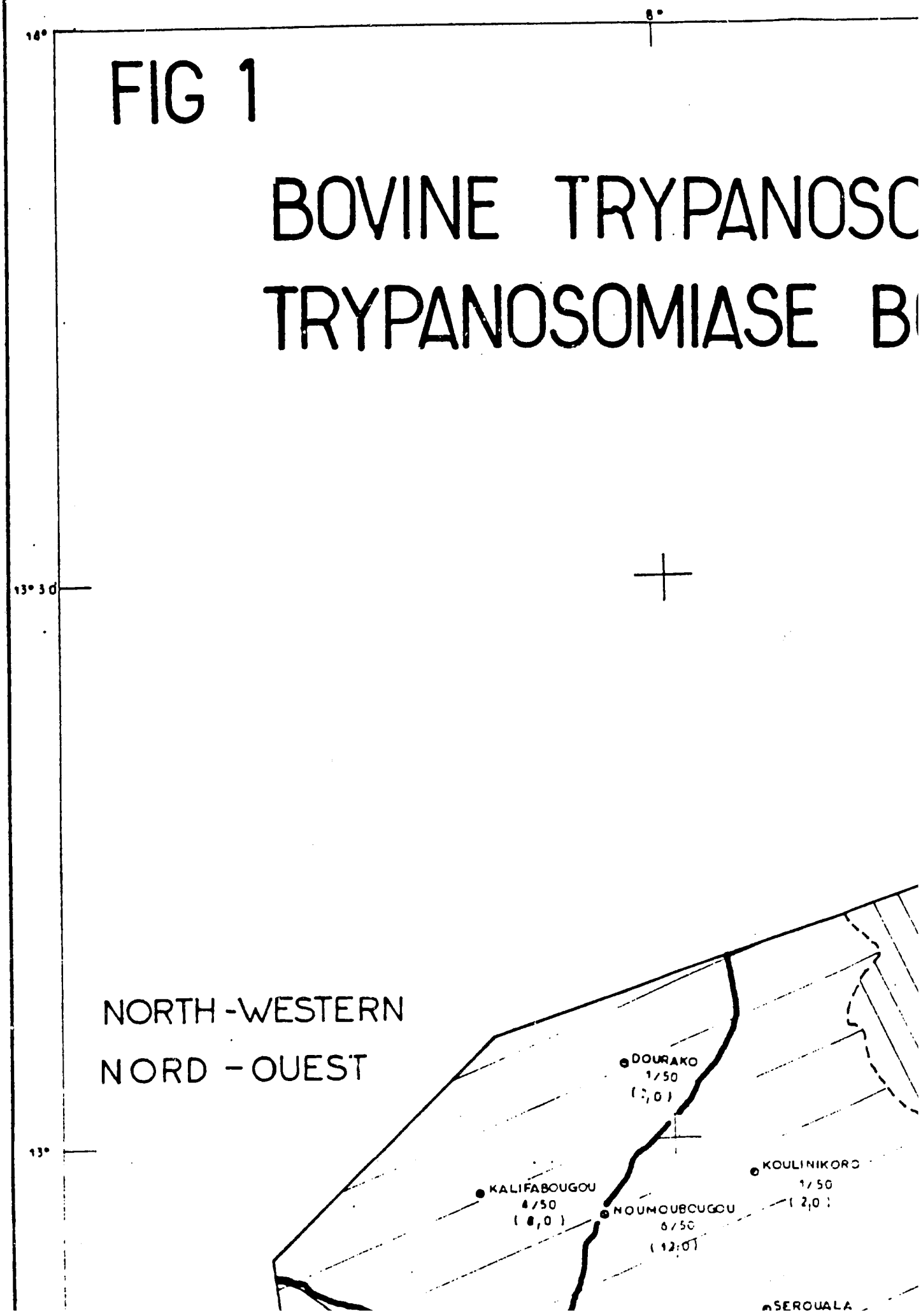
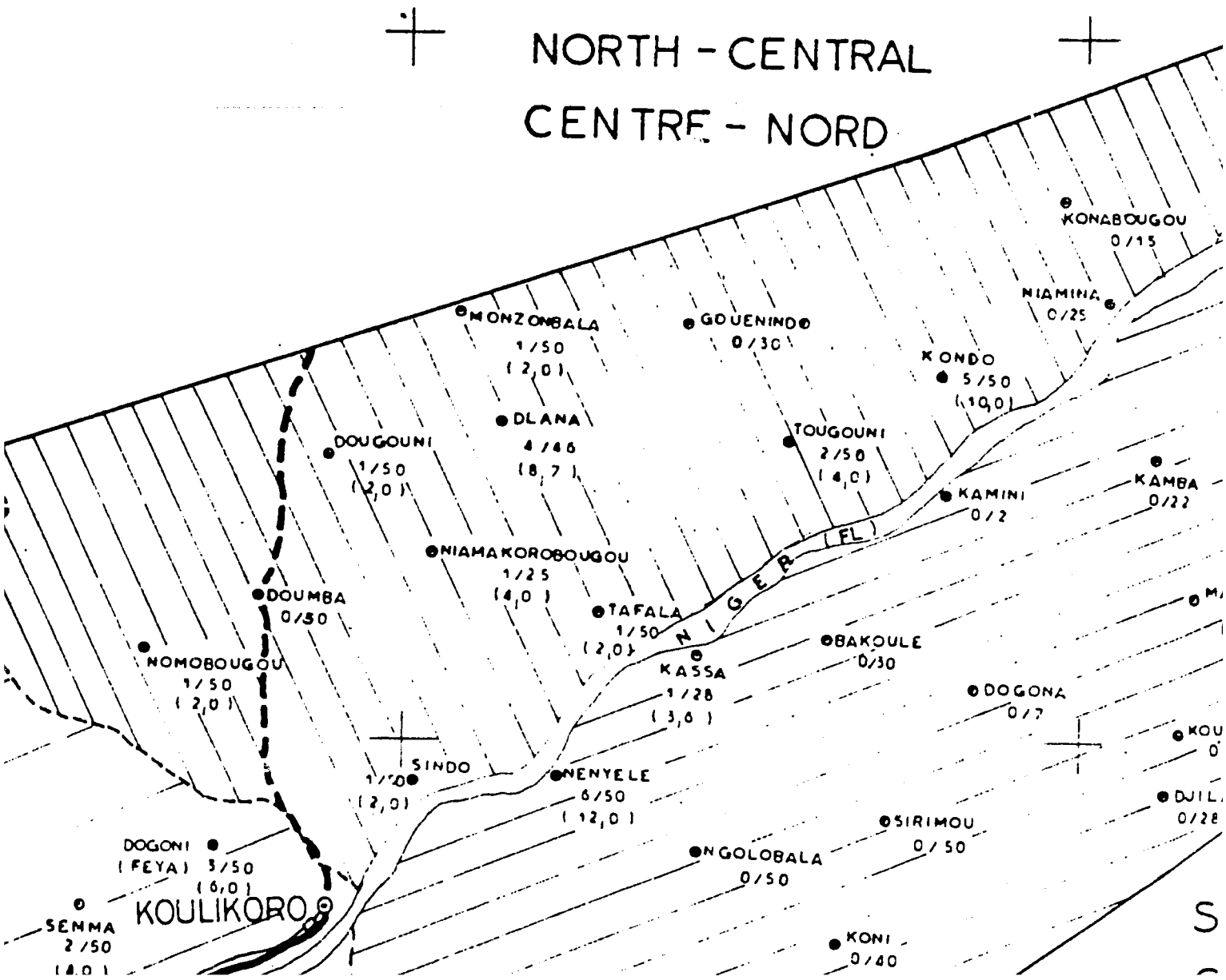
FIG 1

BOVINE TRYPANOSC
TRYPANOSOMIASE B



SOMIASIS : DRY SEASON SUR
BOVINE : ENQUETES DE SAIS



RY SEASON SURVEY

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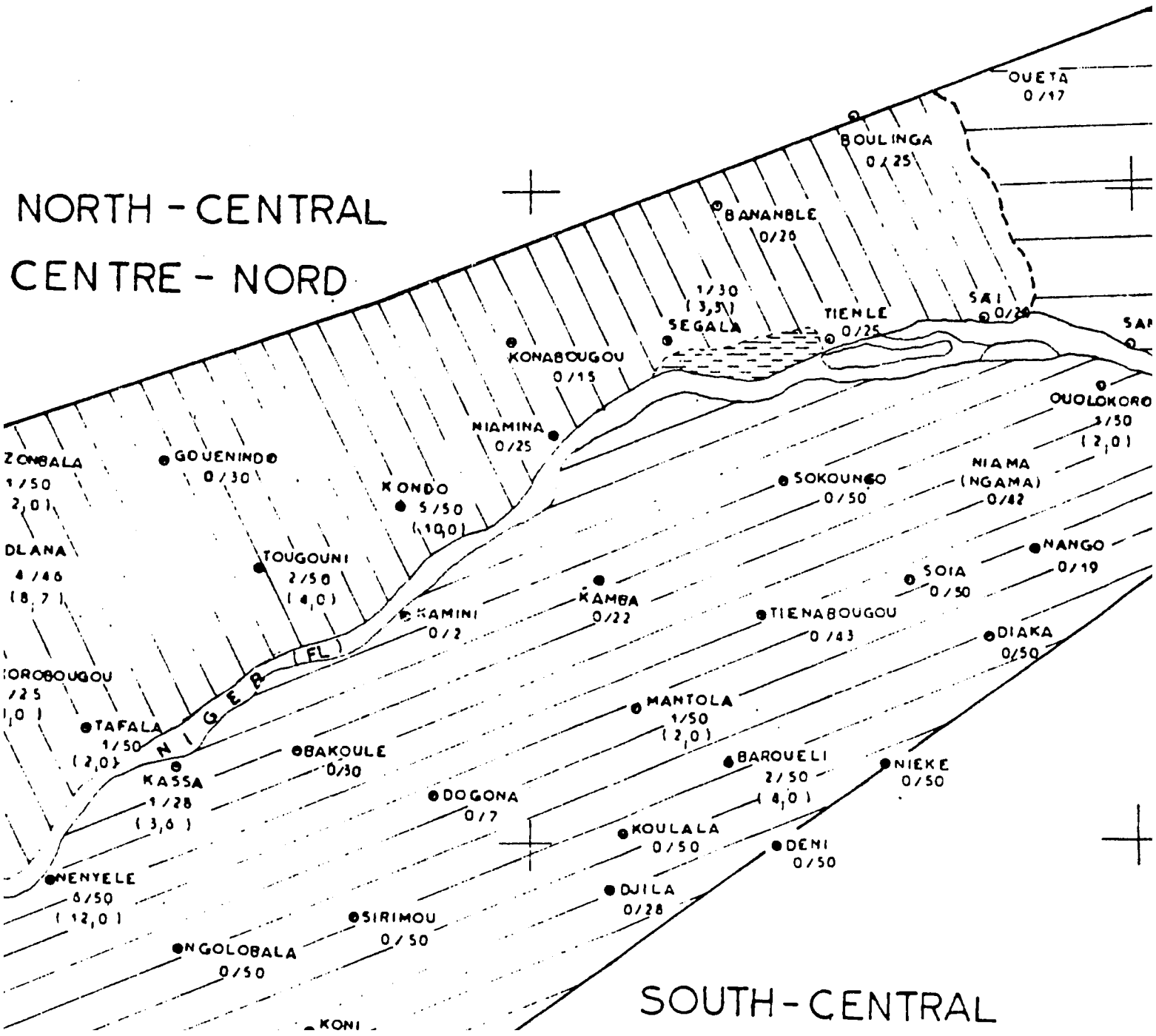

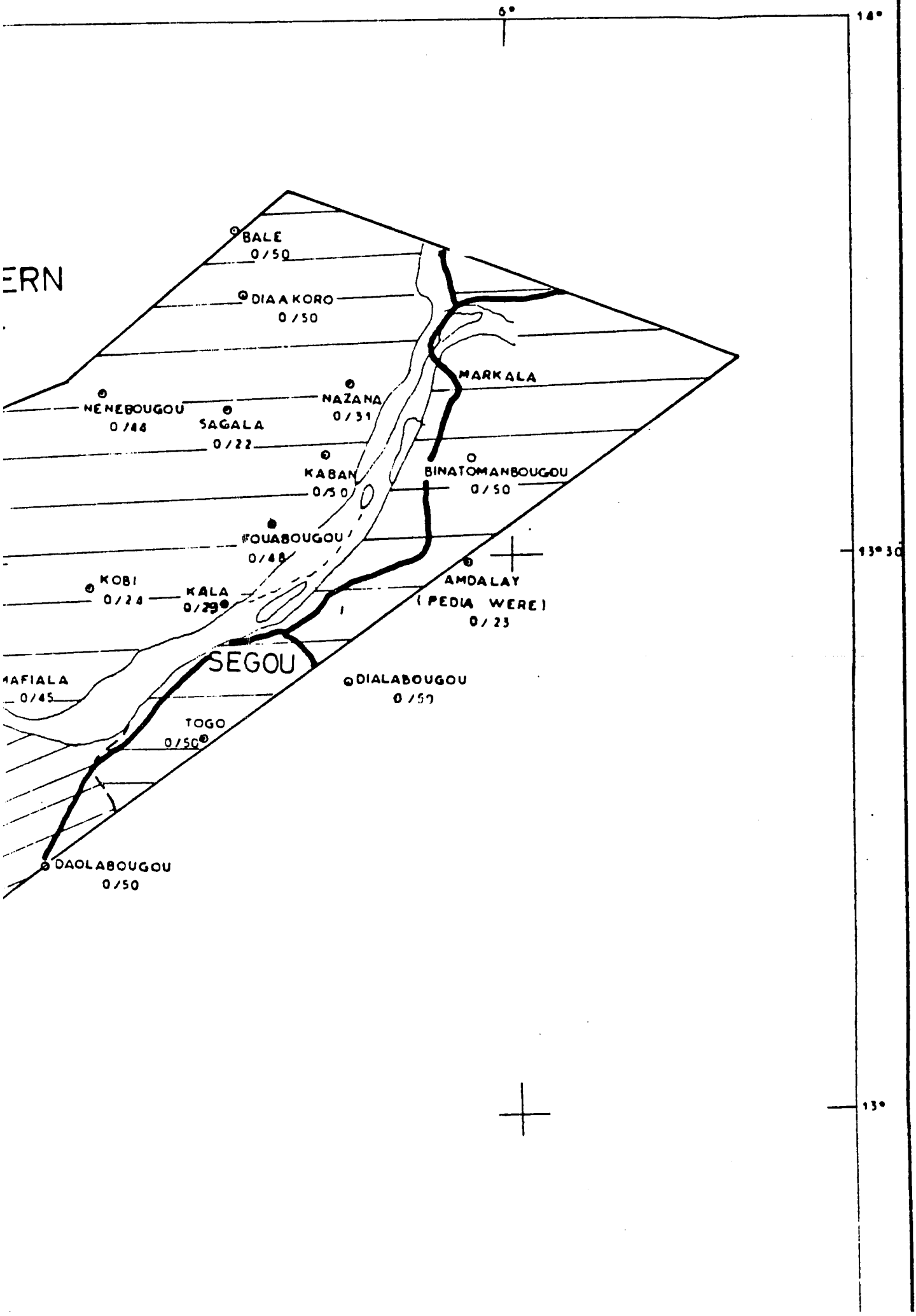
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SAGALA
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KABAN
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BINATOMANBOUGOU
0/50
FOUABOUGOU
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KOBI
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KALA
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AMDALAY
(PEDIA WERE)
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SEGOU
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DIALABOUGOU
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TOGO
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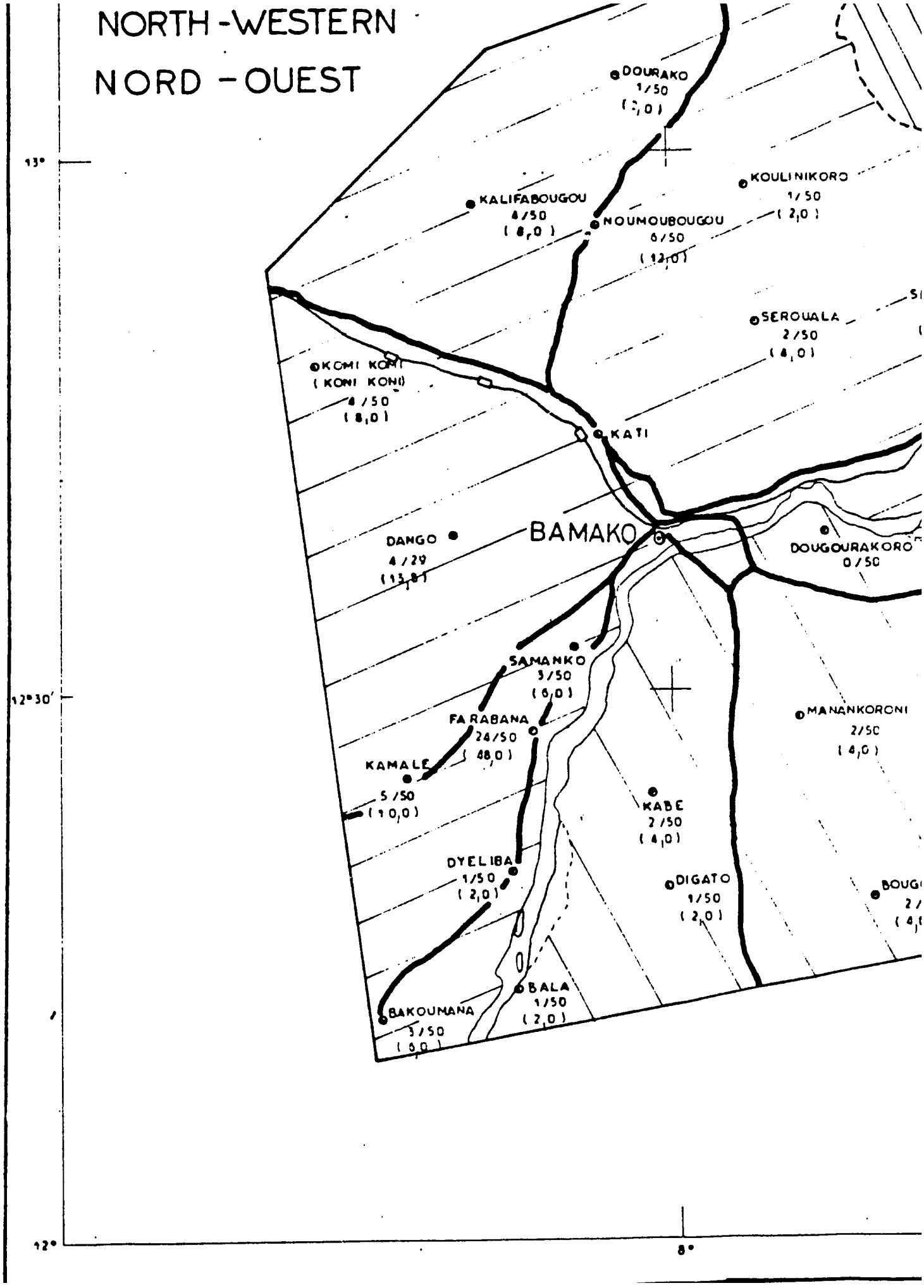
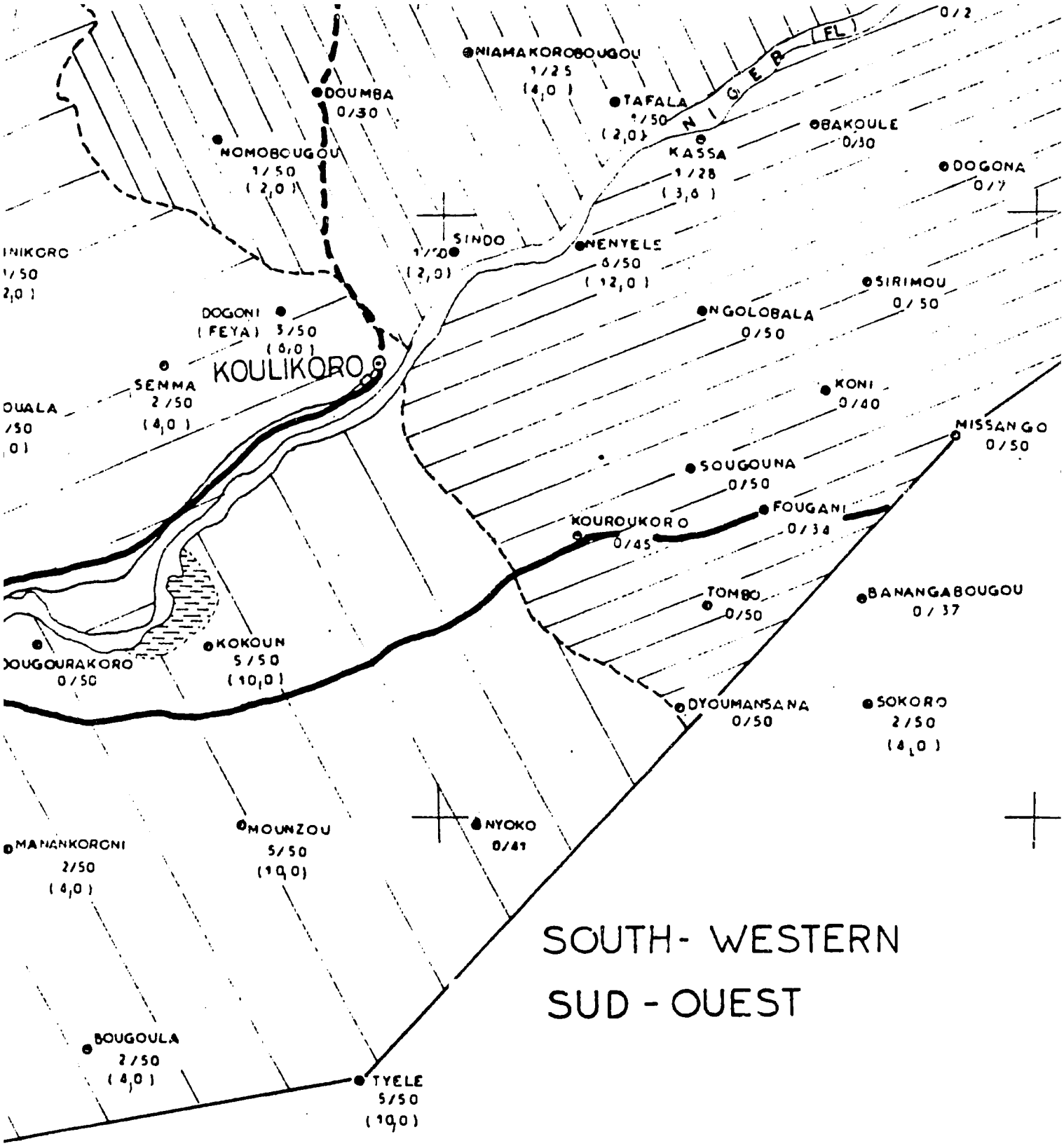
NORTH-WESTERN
NORD-OUEST

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NIGER (FL)
BAKOULE
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NOMOBOUGOU
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DOGONA
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SIRIMOU
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KOUROUKORO
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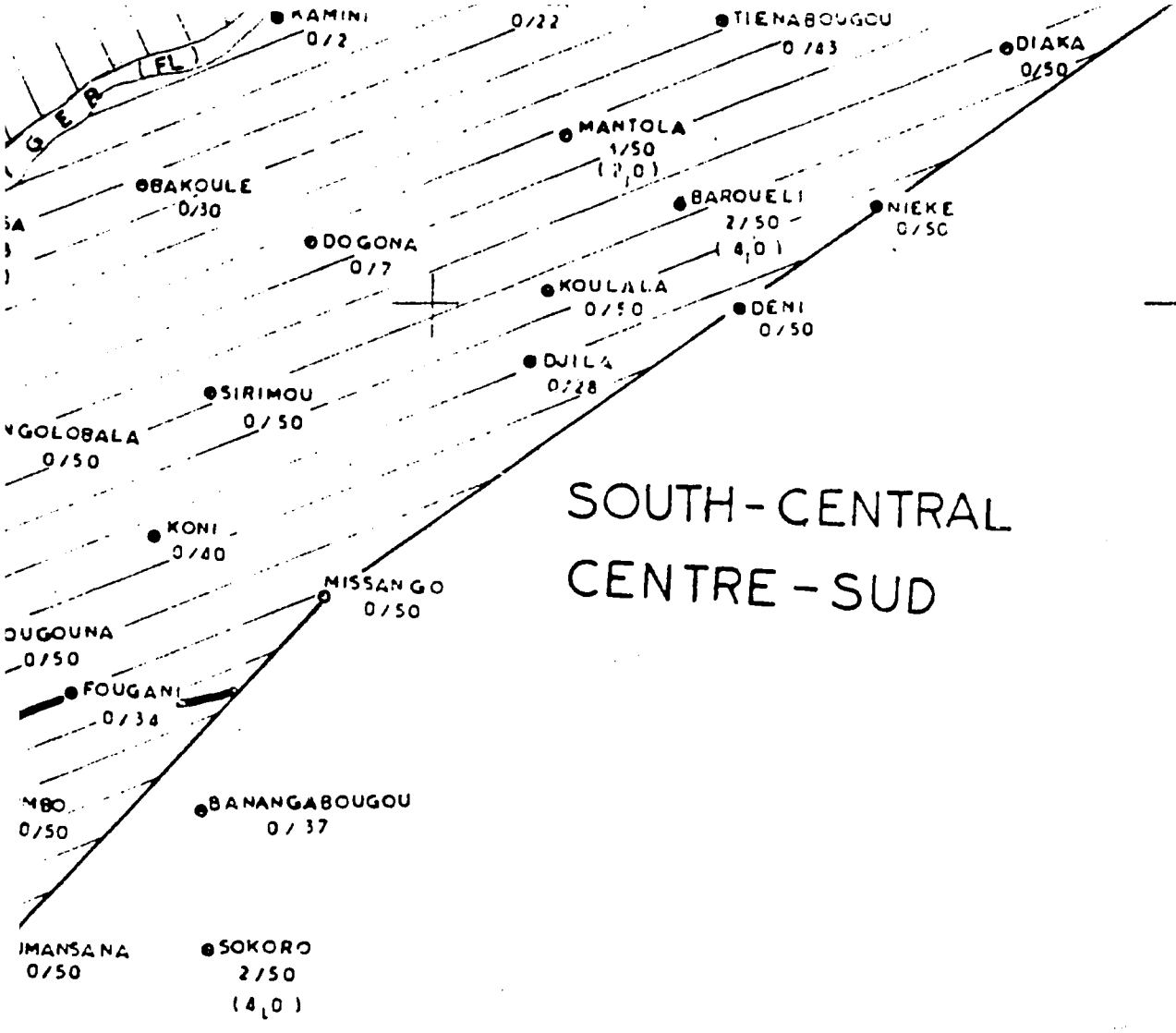

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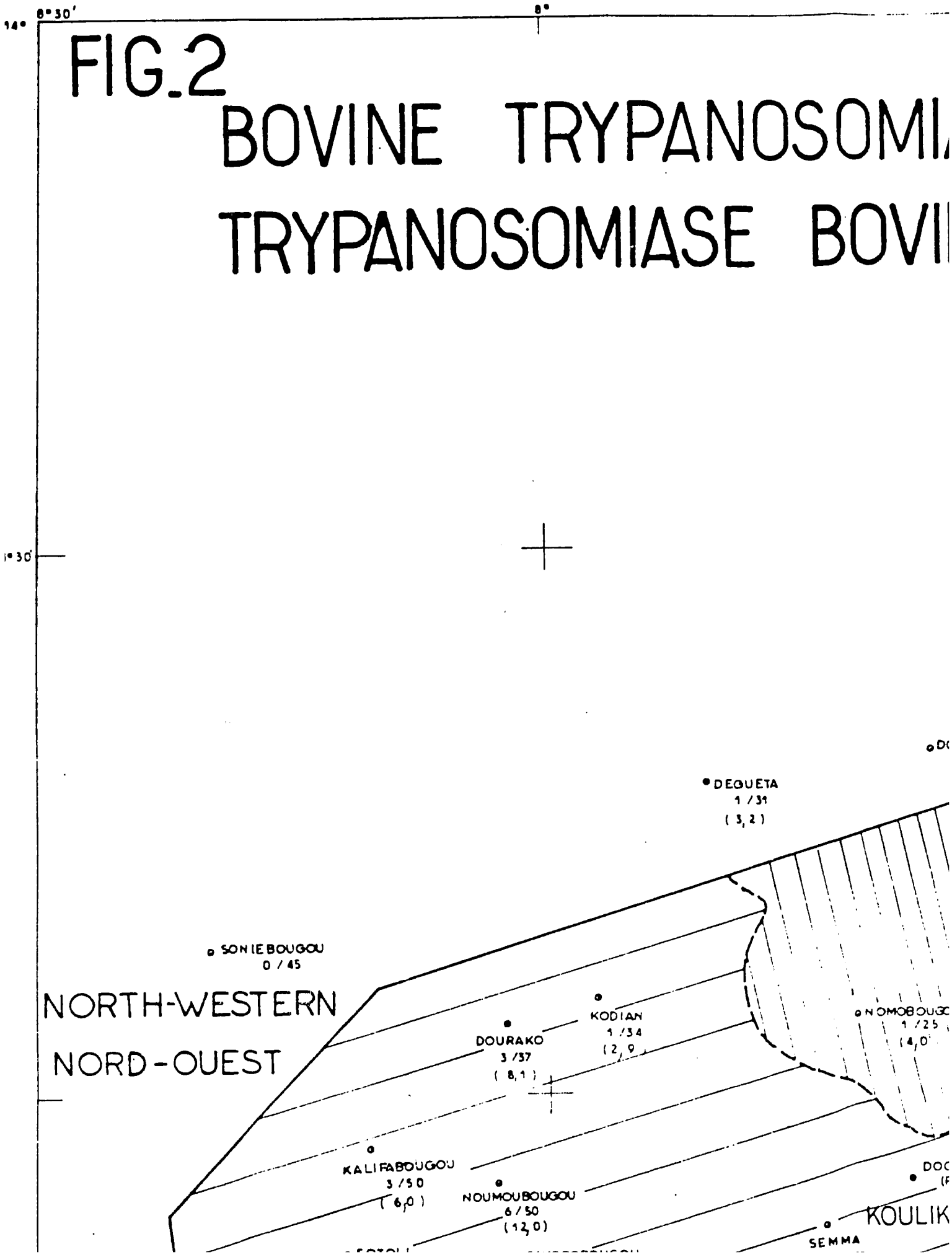
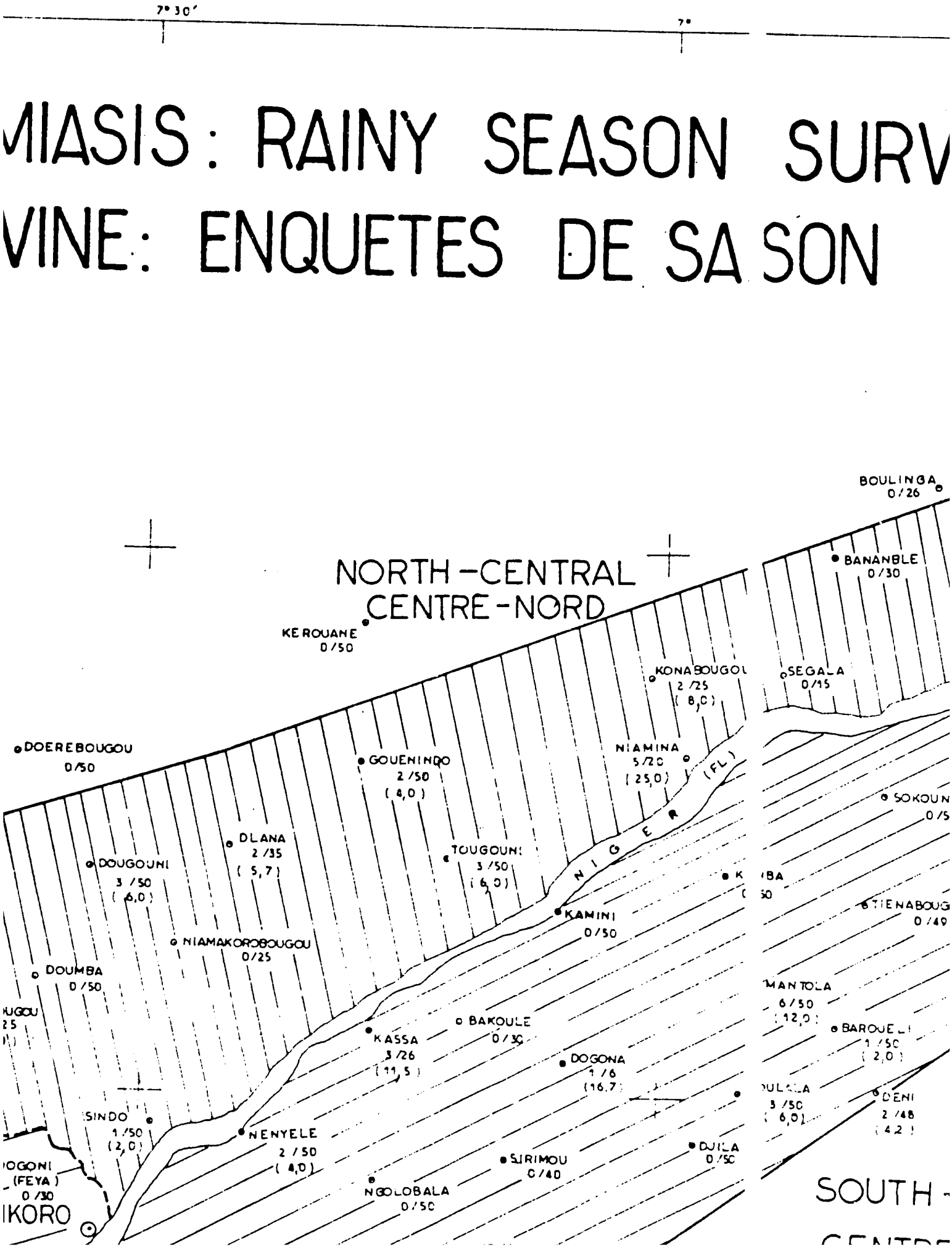
FIG.2

BOVINE TRYPANOSOMI

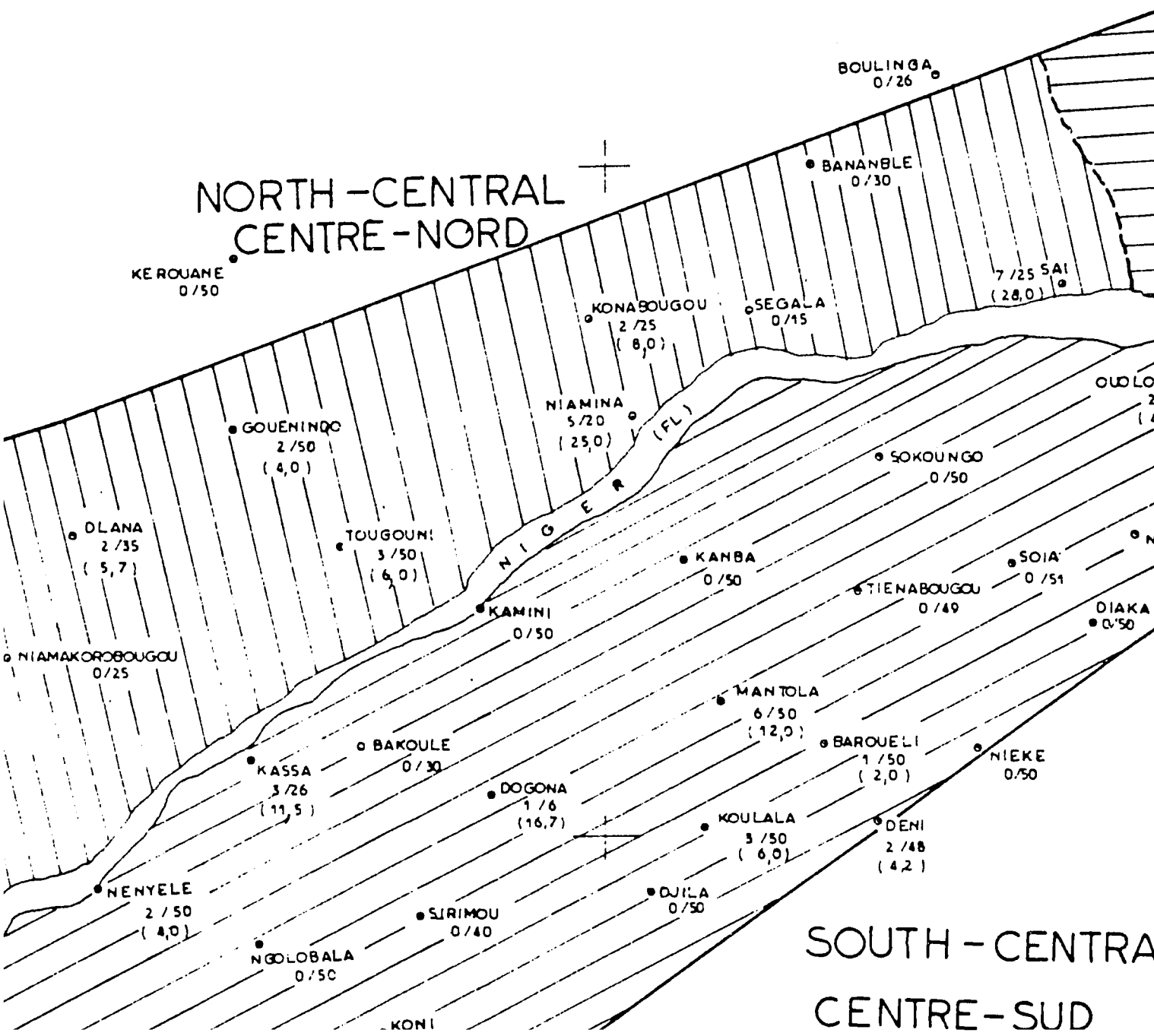
TRYPANOSOMIASE BOVI

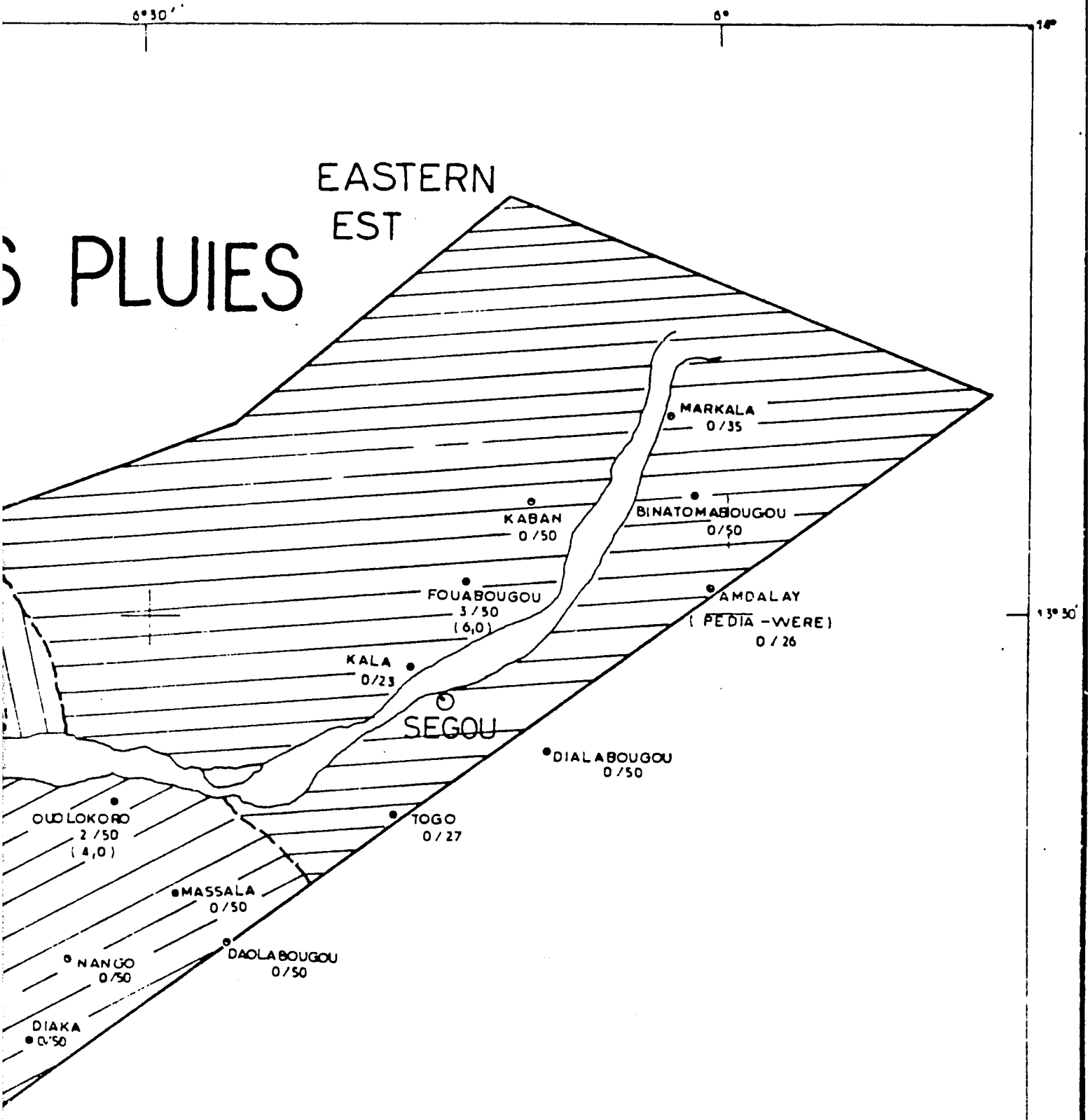


MIASIS: RAINY SEASON SURV
VINE: ENQUETES DE SA SON



RAINY SEASON SURVEY
ENQUETES DE SAISON DES F

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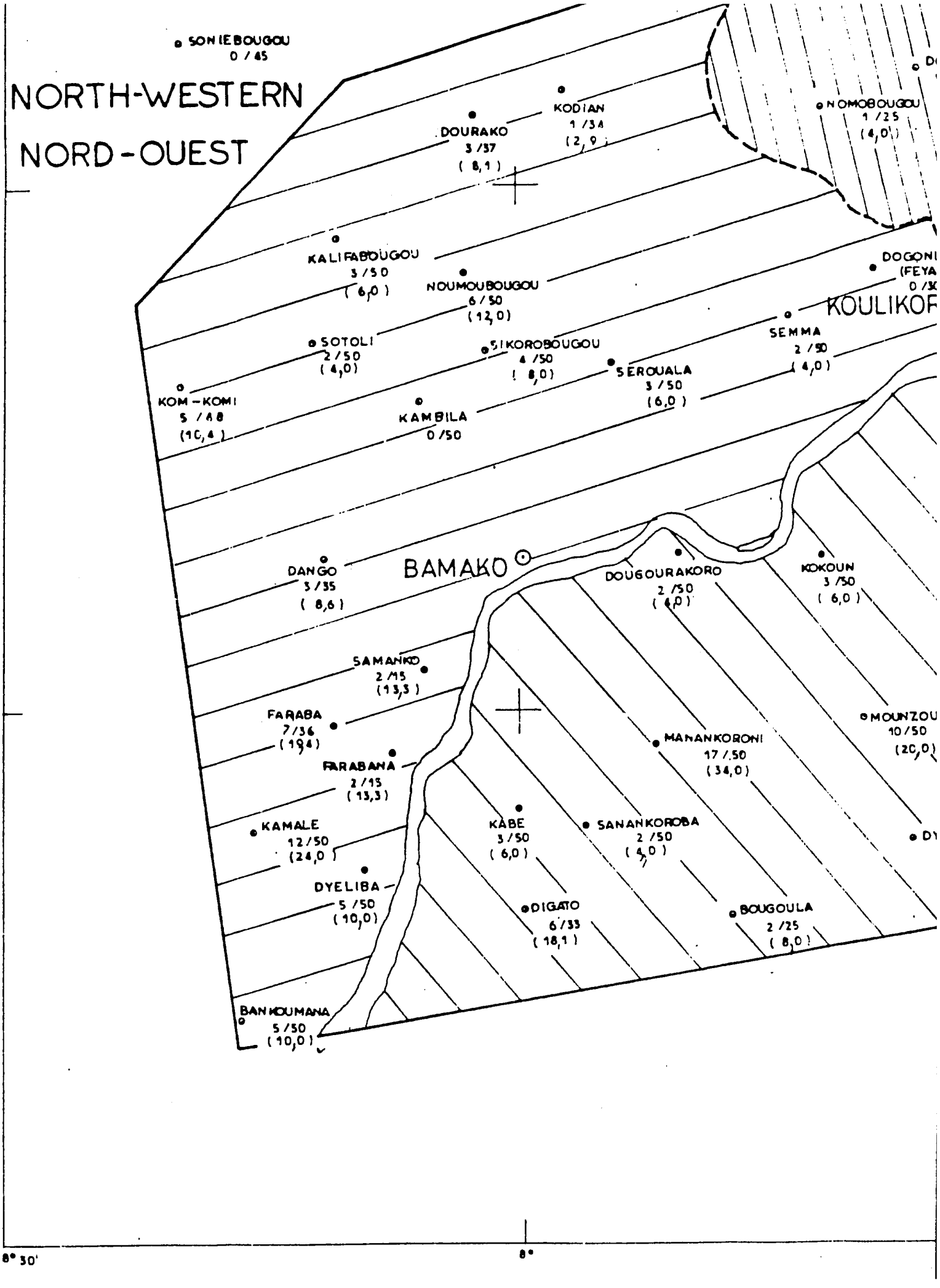
NORTH-WESTERN
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SONIEBOUGOU
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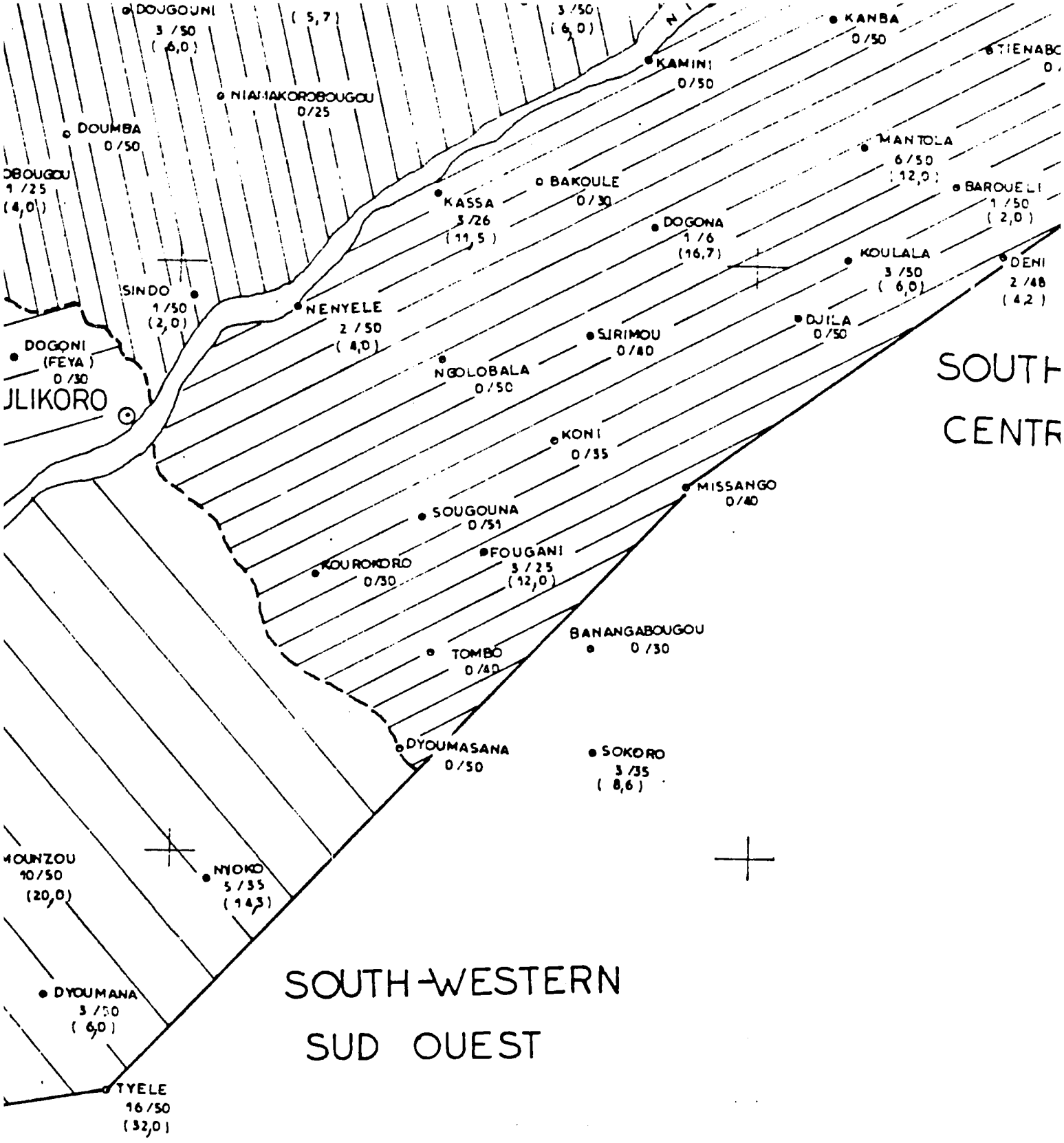

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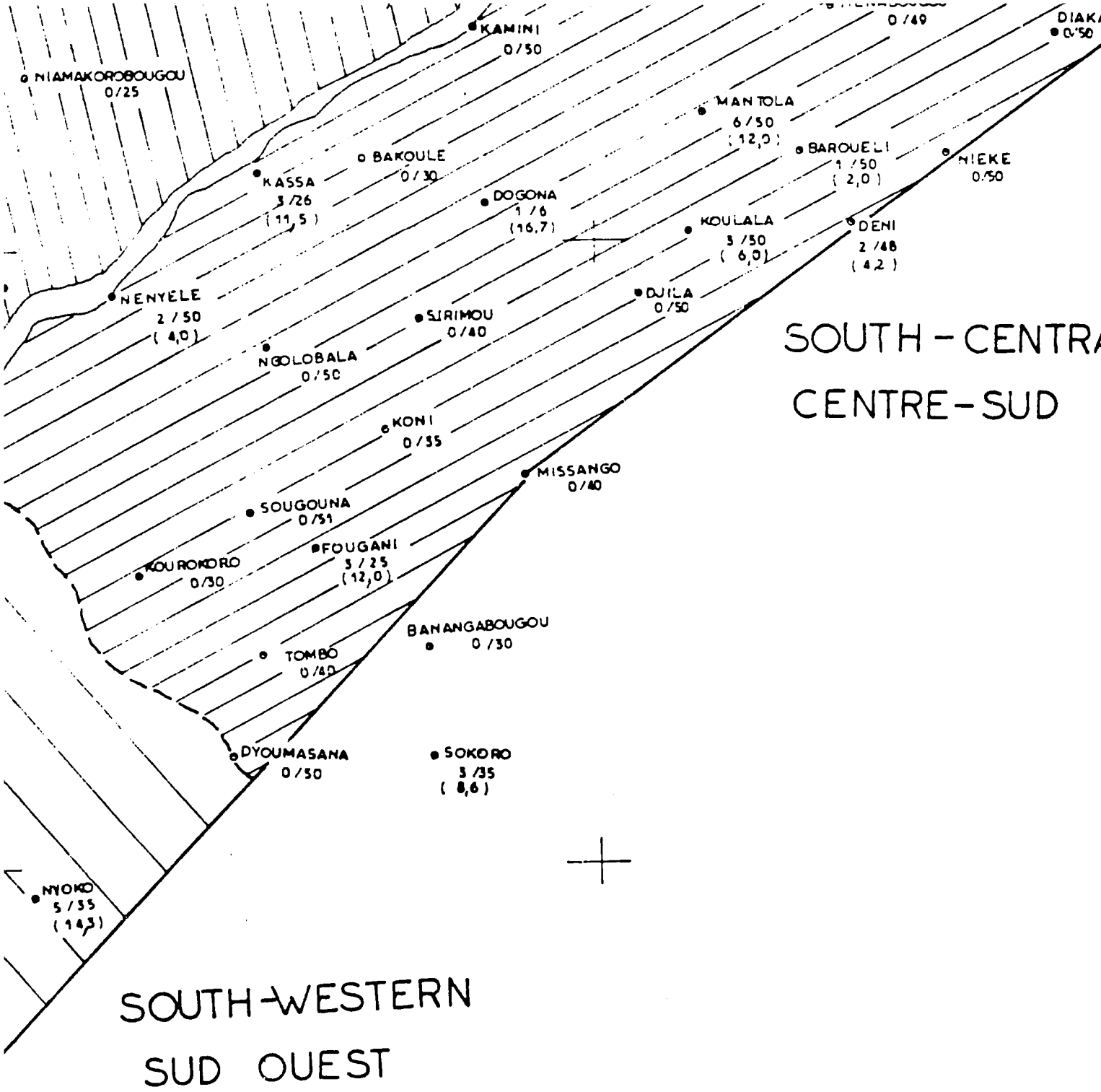

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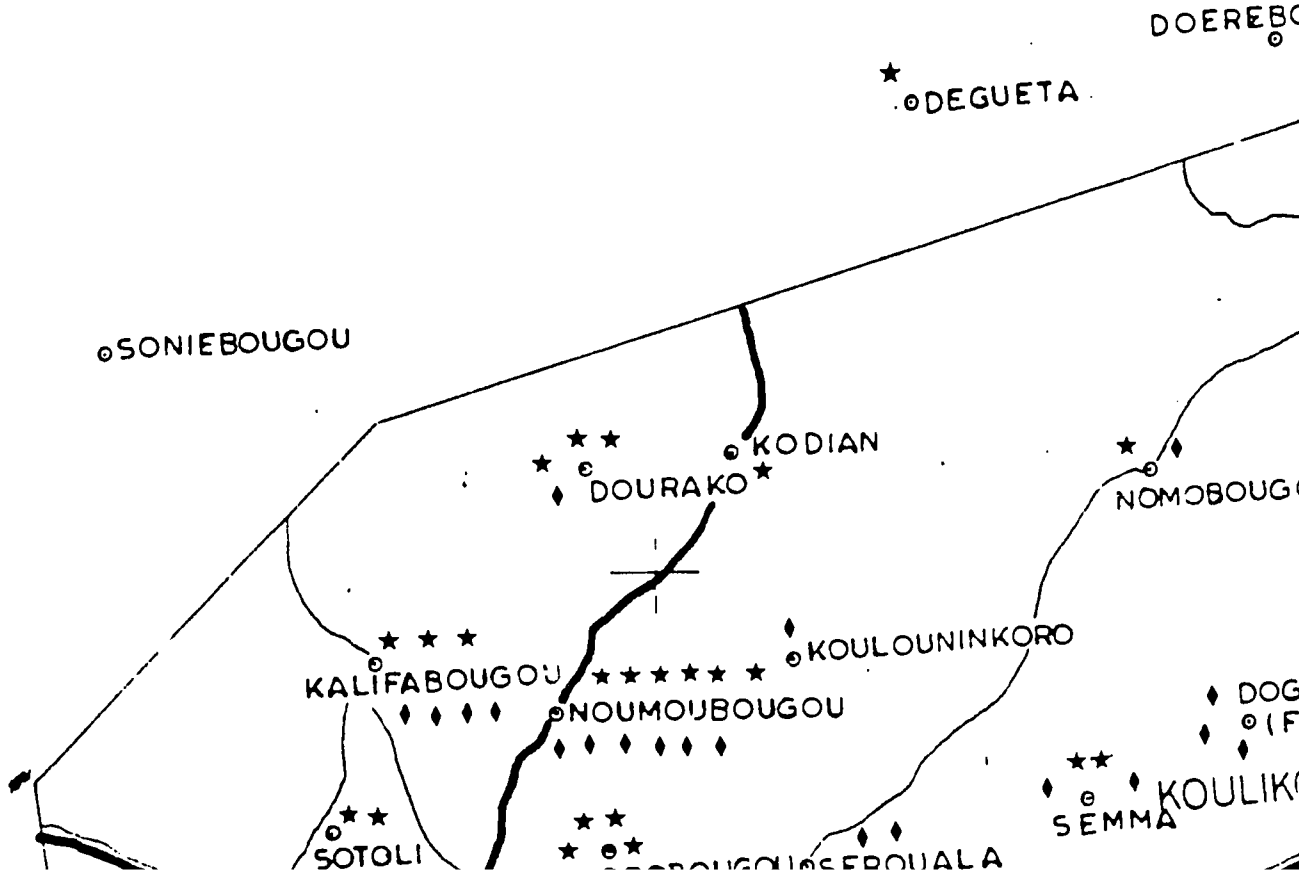
FIG 3

BOVINE TRYPANOSOMIASIS
TRYPANOSOMIASE BOVINE

★ RAINY SEASON INCIDENCE
INCIDENCE DE SAISON DE PLUIES

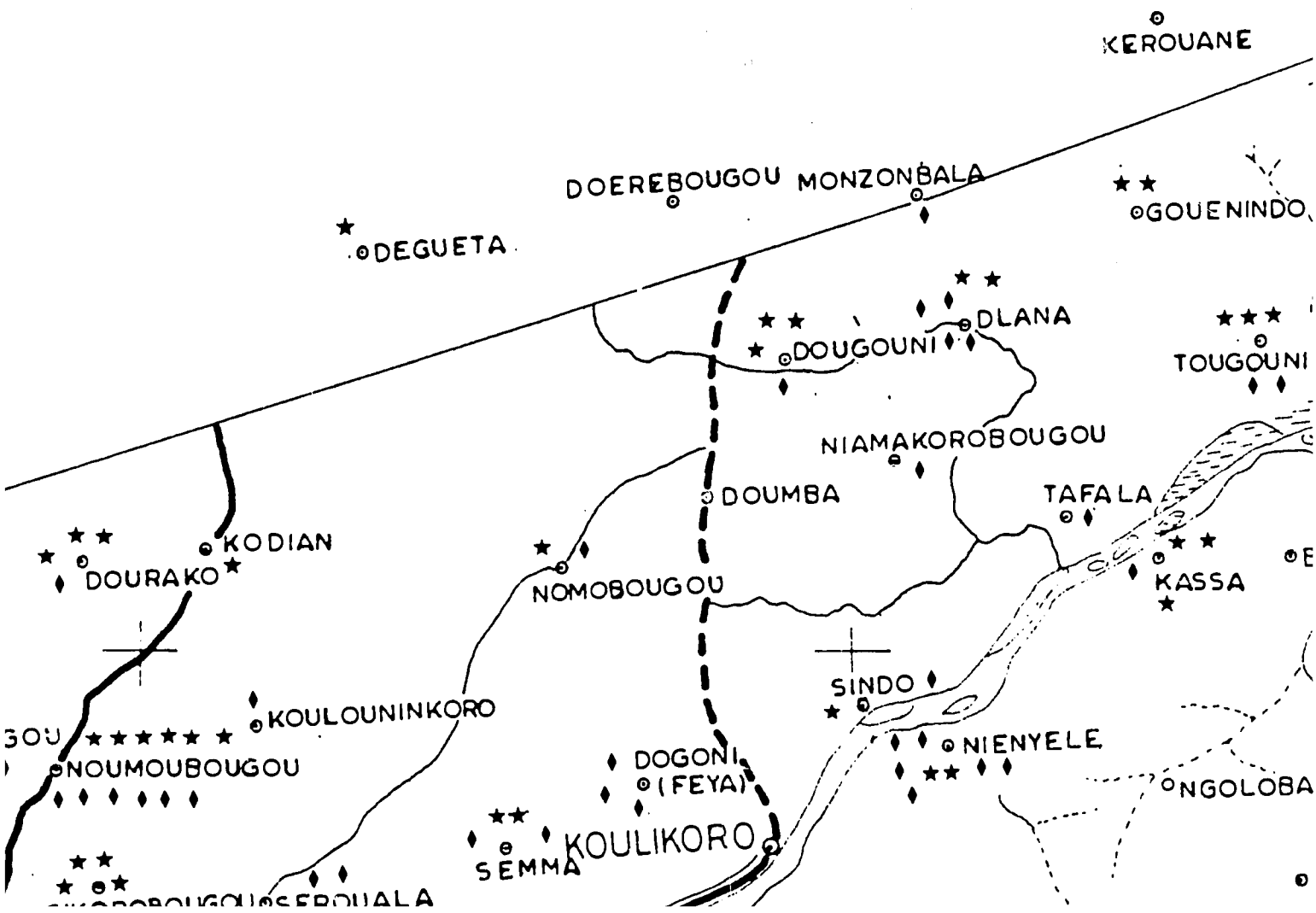
♦ DRY SEASON INCIDENCE.
INCIDENCE DE SAISON SECHE



RYPANOSOMIASIS: SEASONAL
SOMIASE BOVINE: VARIATION

ON INCIDENCE
DE SAISON DE PLUIES

INCIDENCE.
DE SAISON SECHE



ASONAL VARIATION
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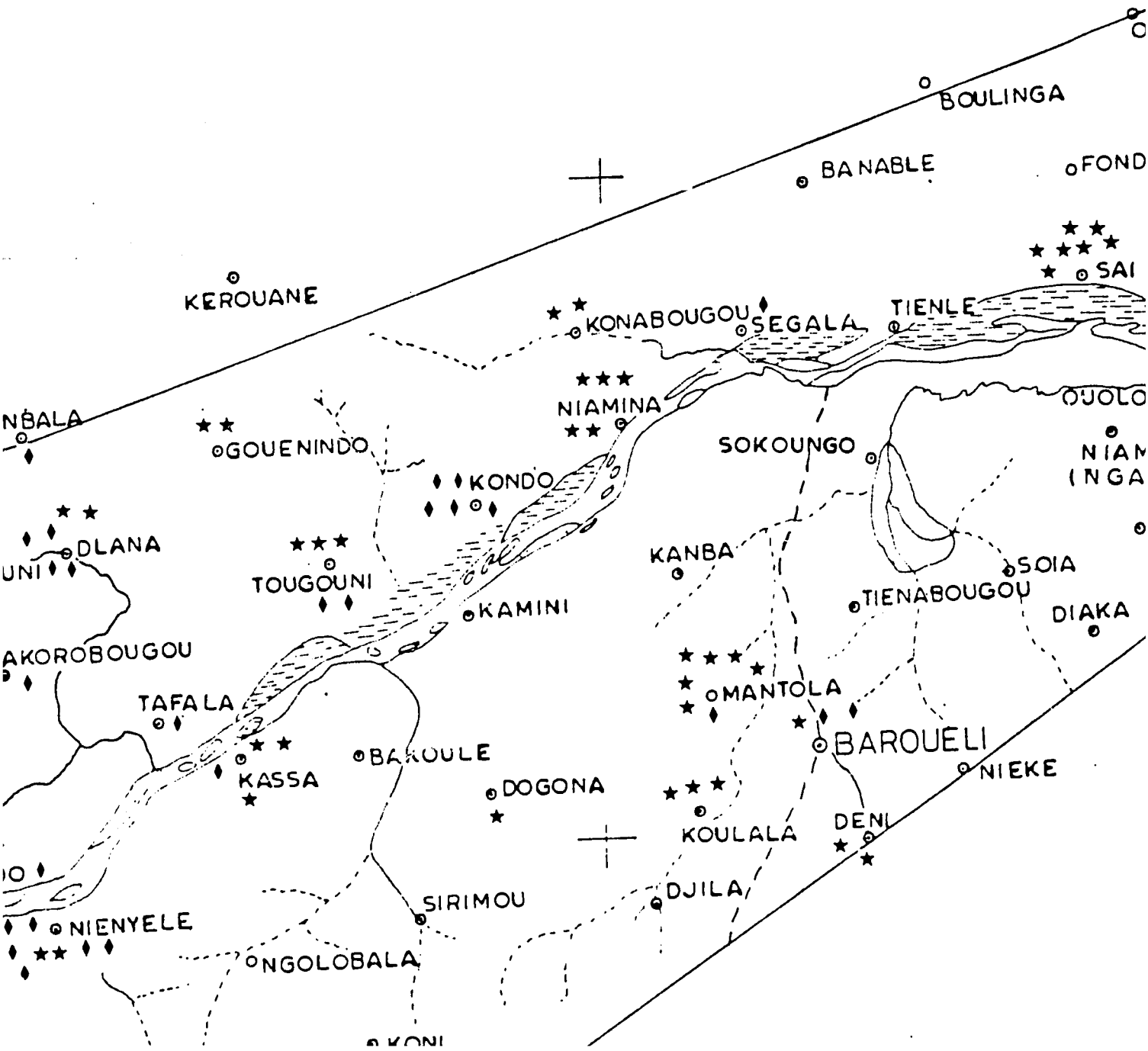

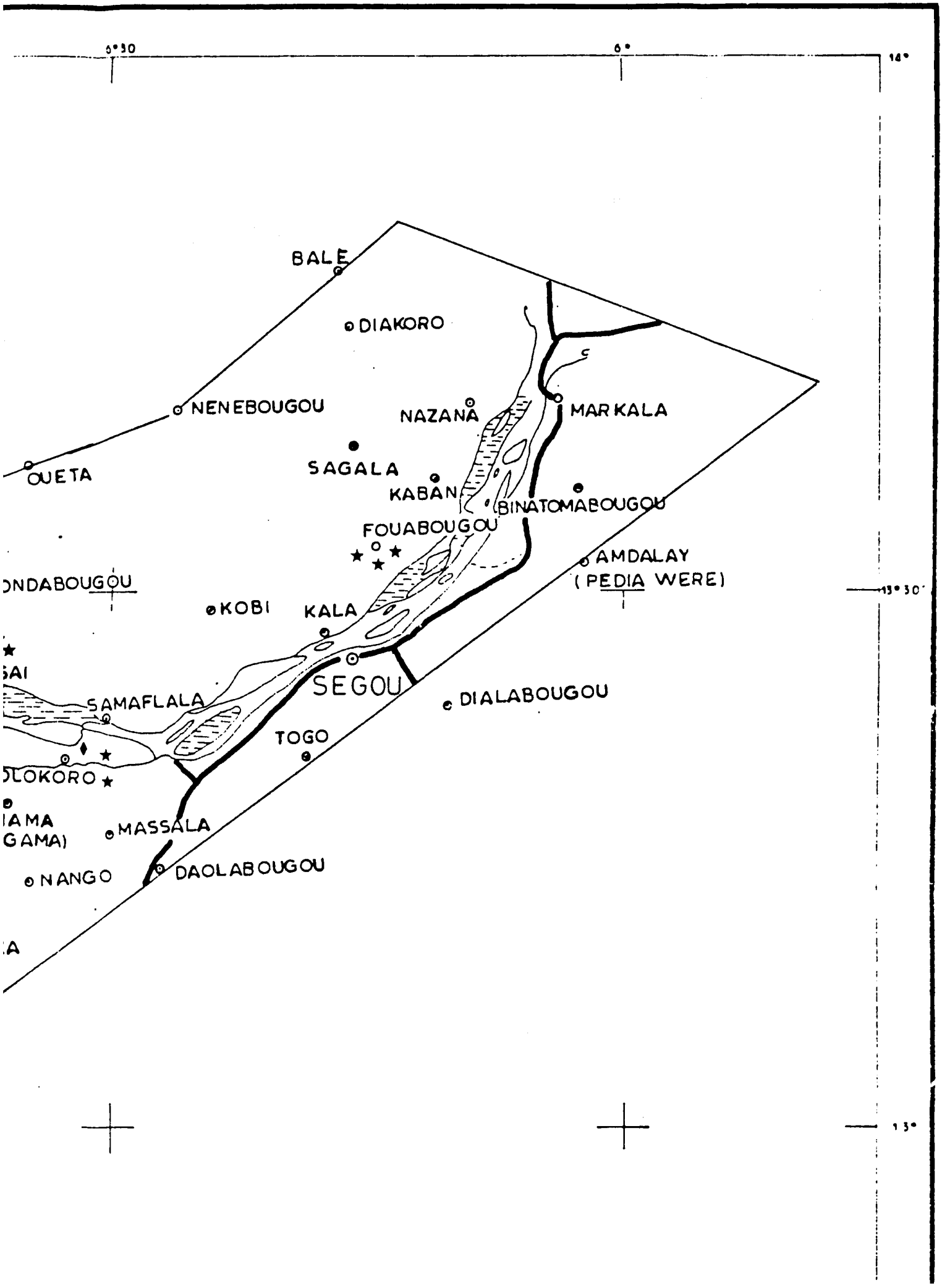
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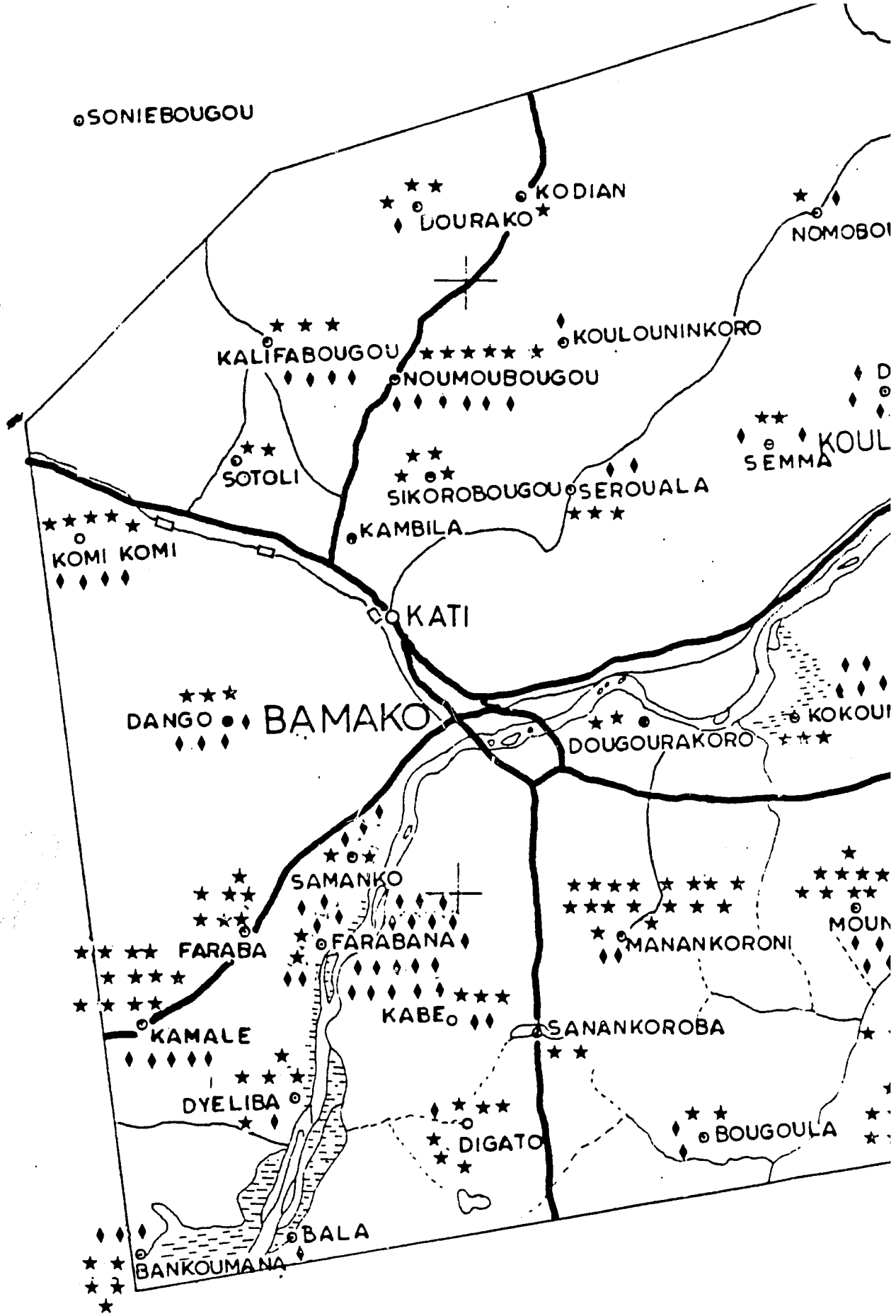
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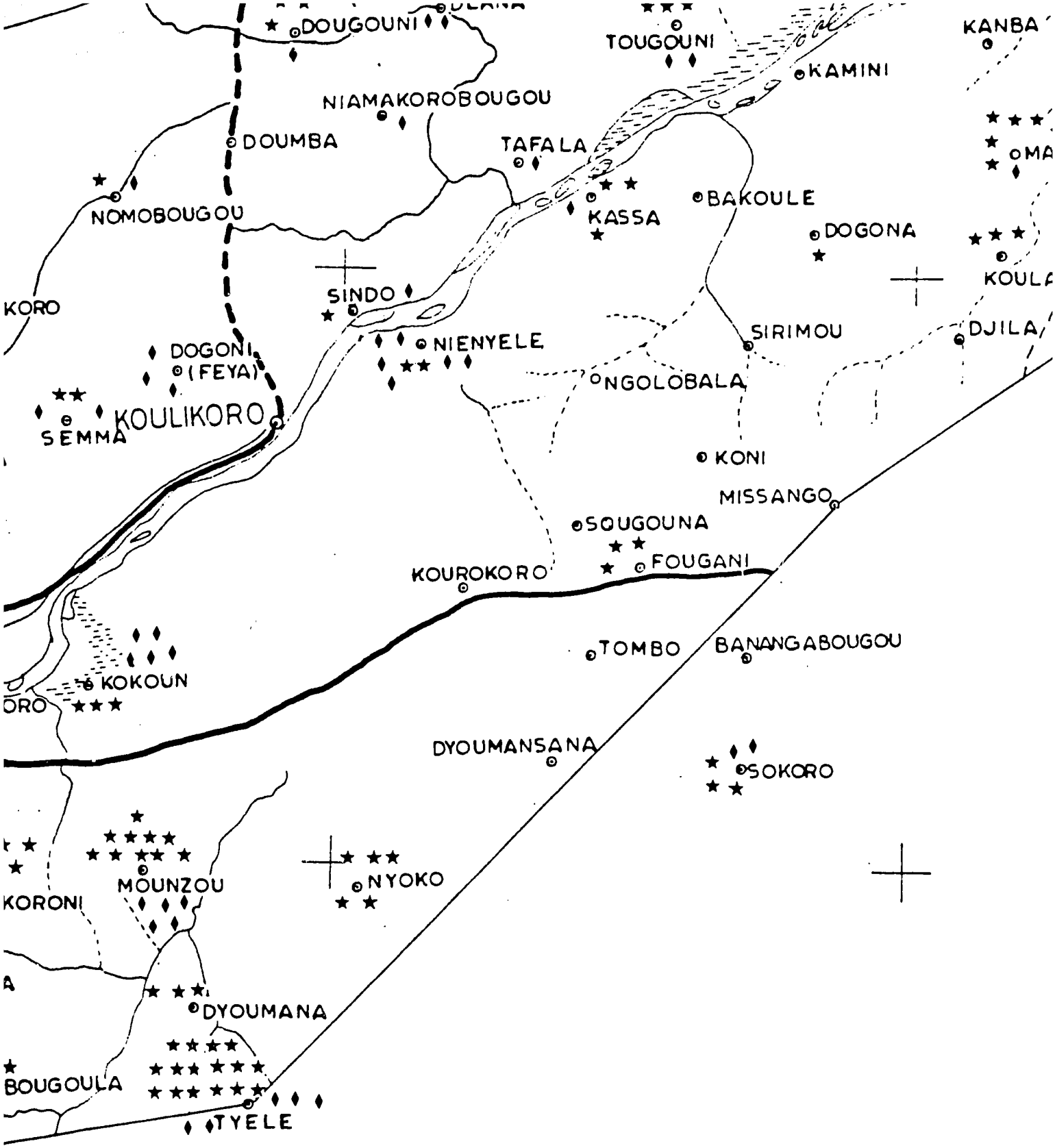

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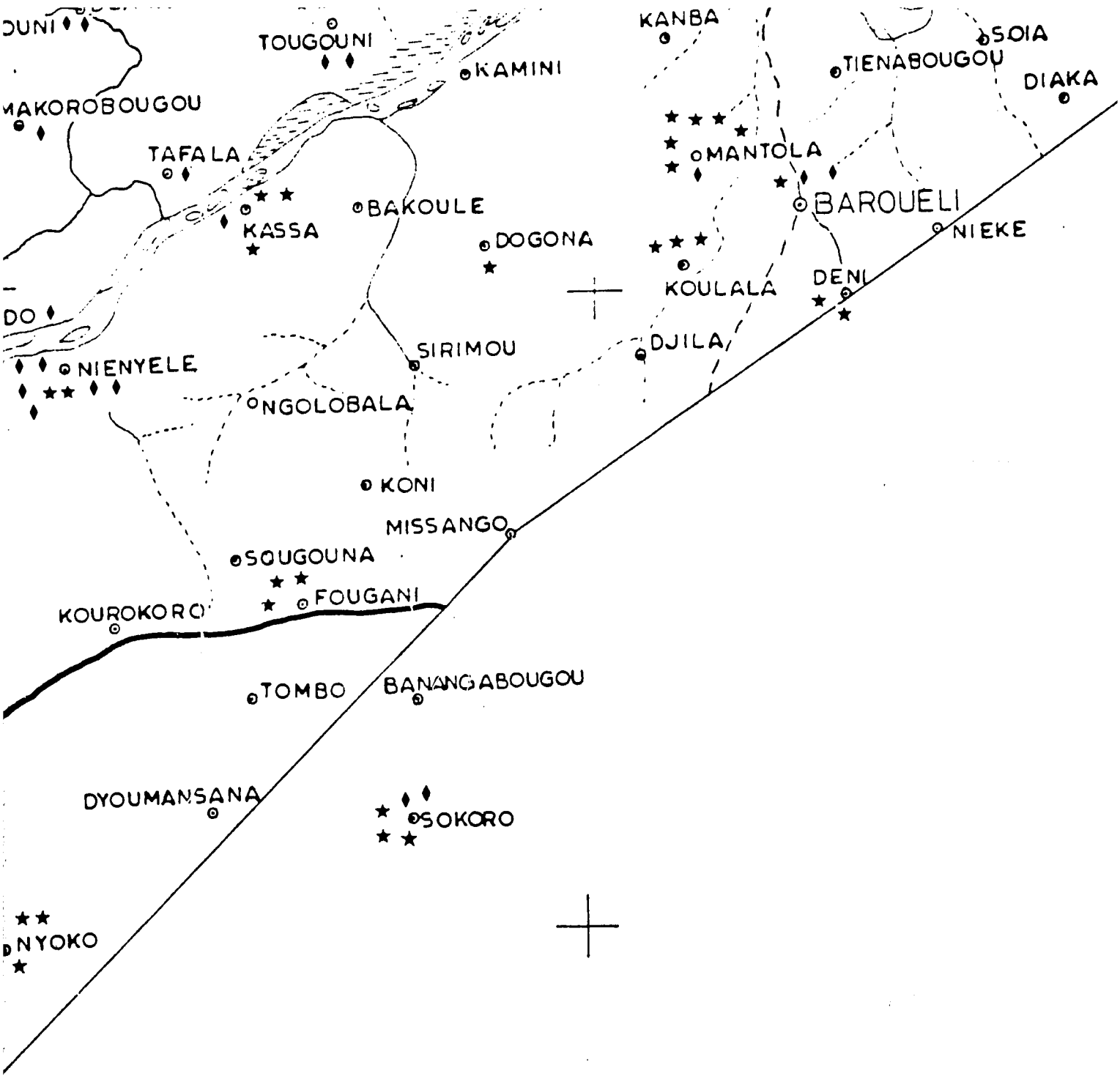

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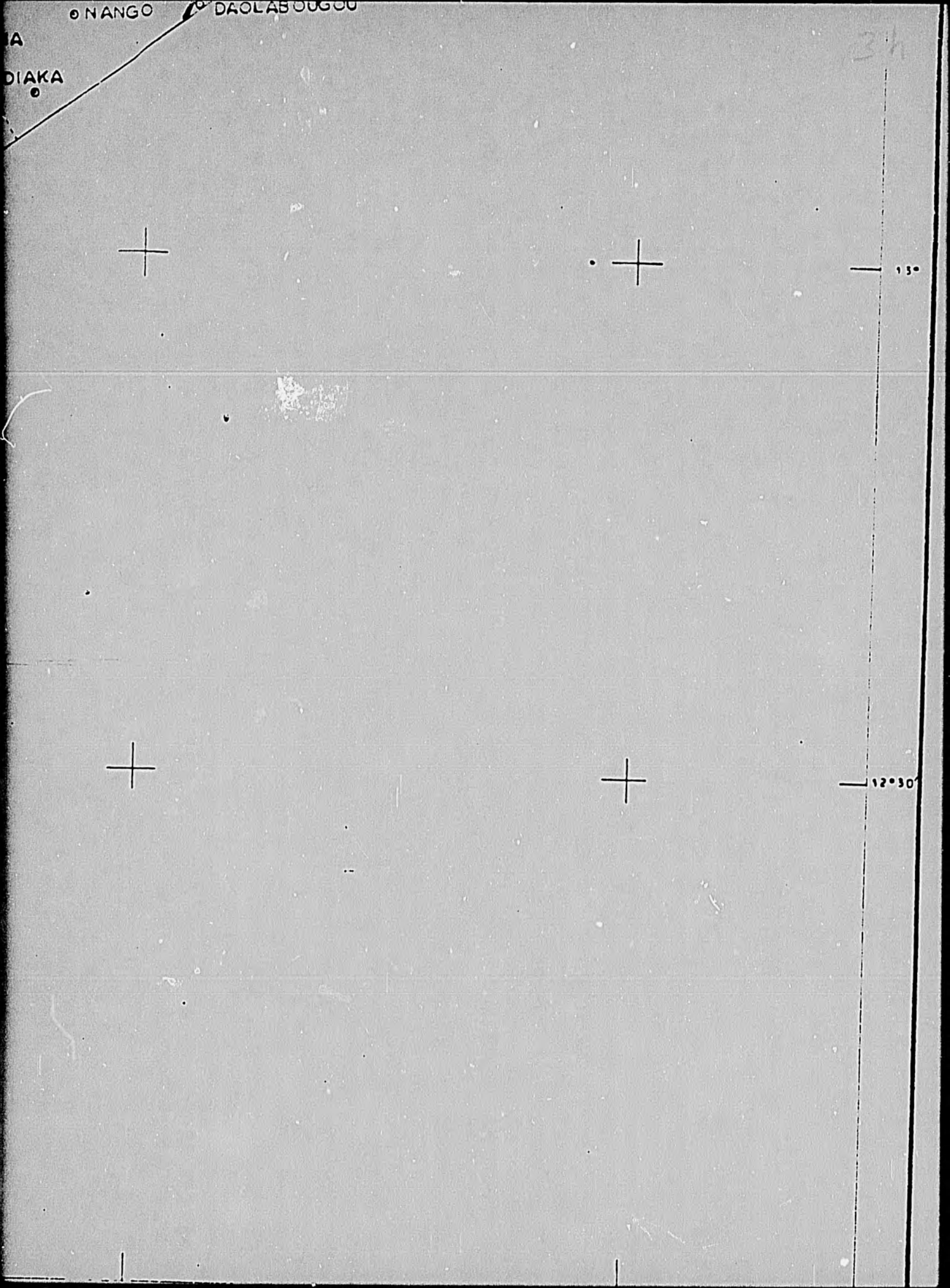
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RELATIVE PREVALENCE OF TRYPANOSOME SPECIES IN VARIOUS SECTORS OF ZONE 1 (DRY SEASON)

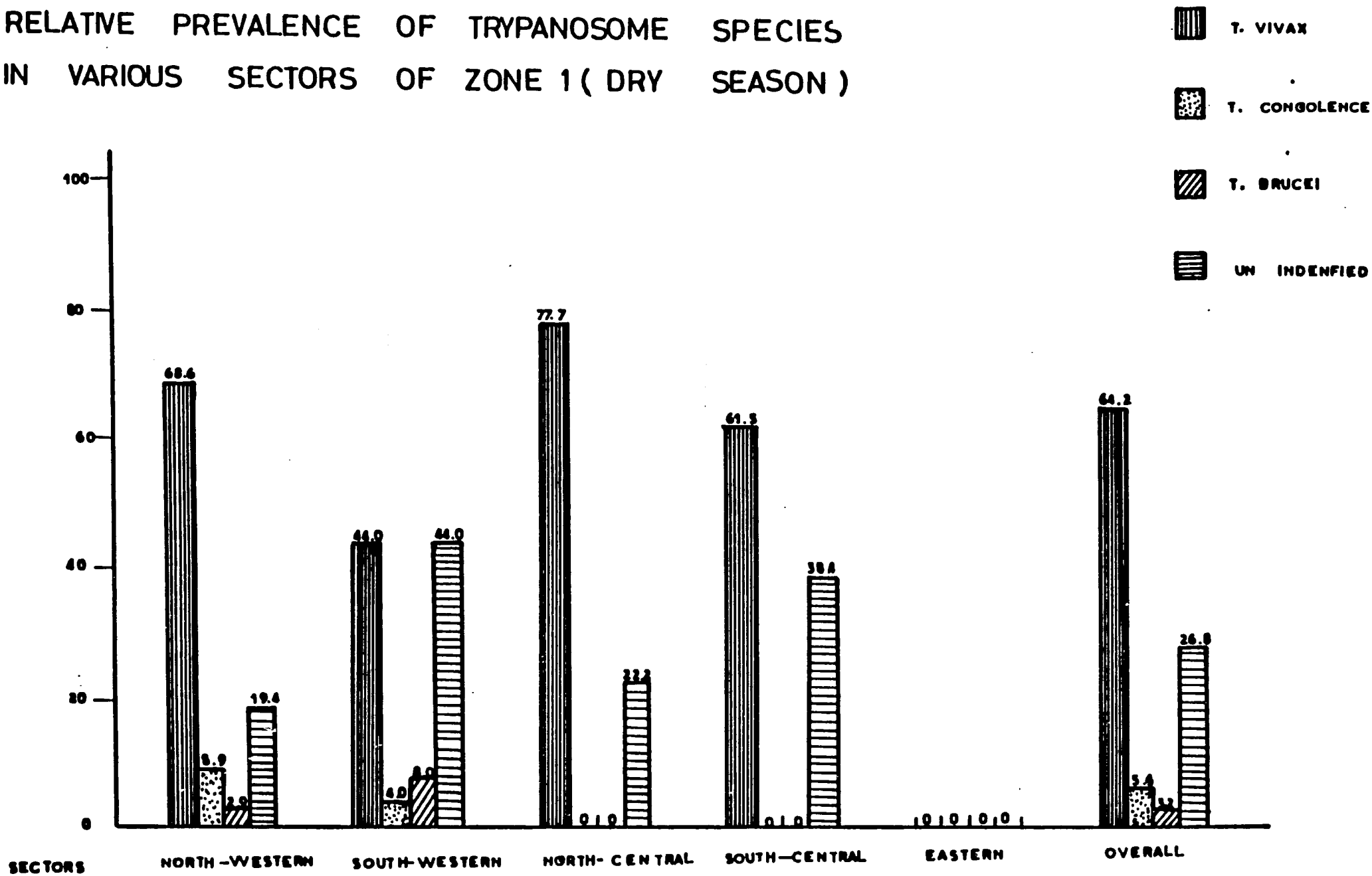

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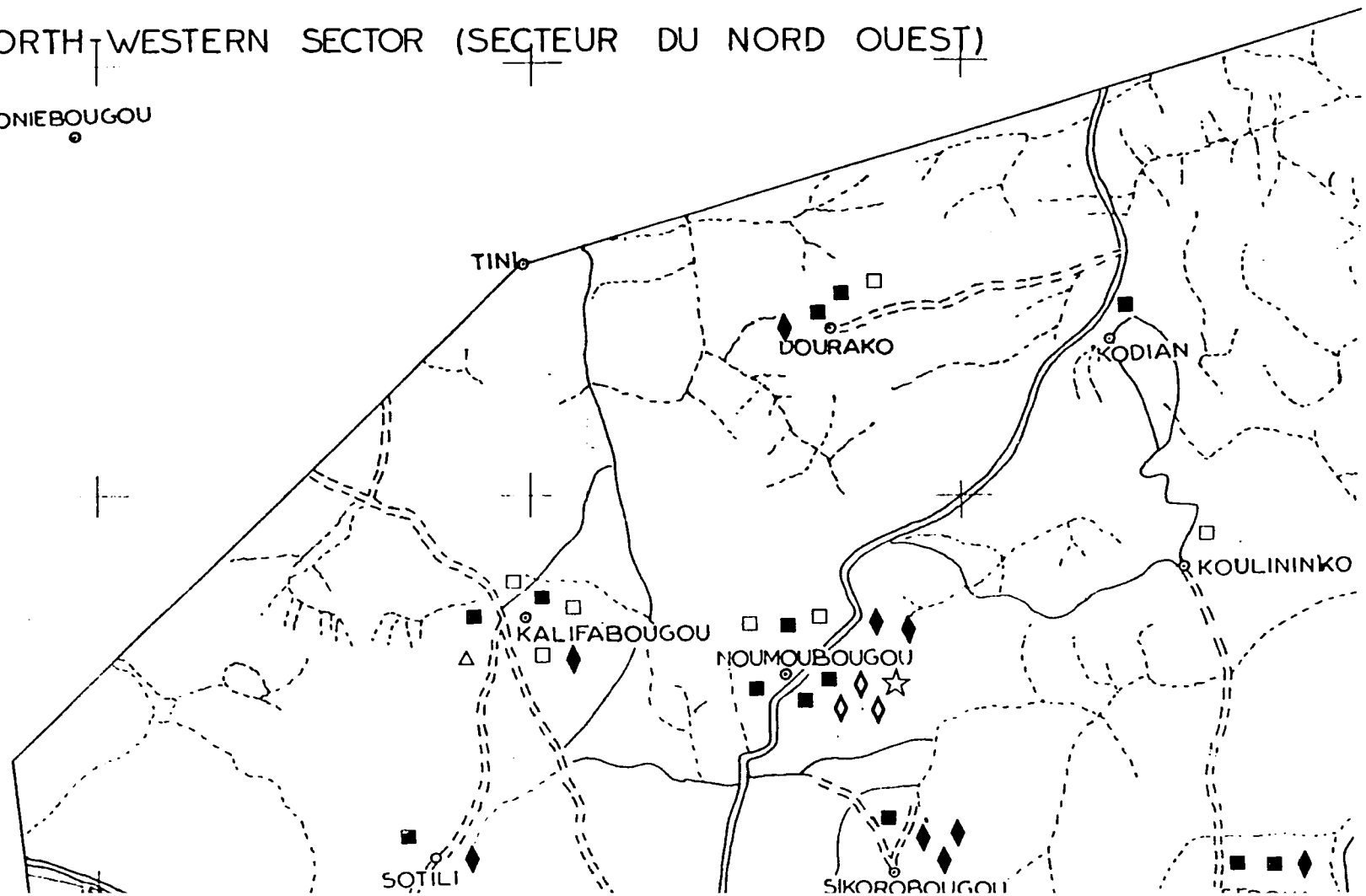
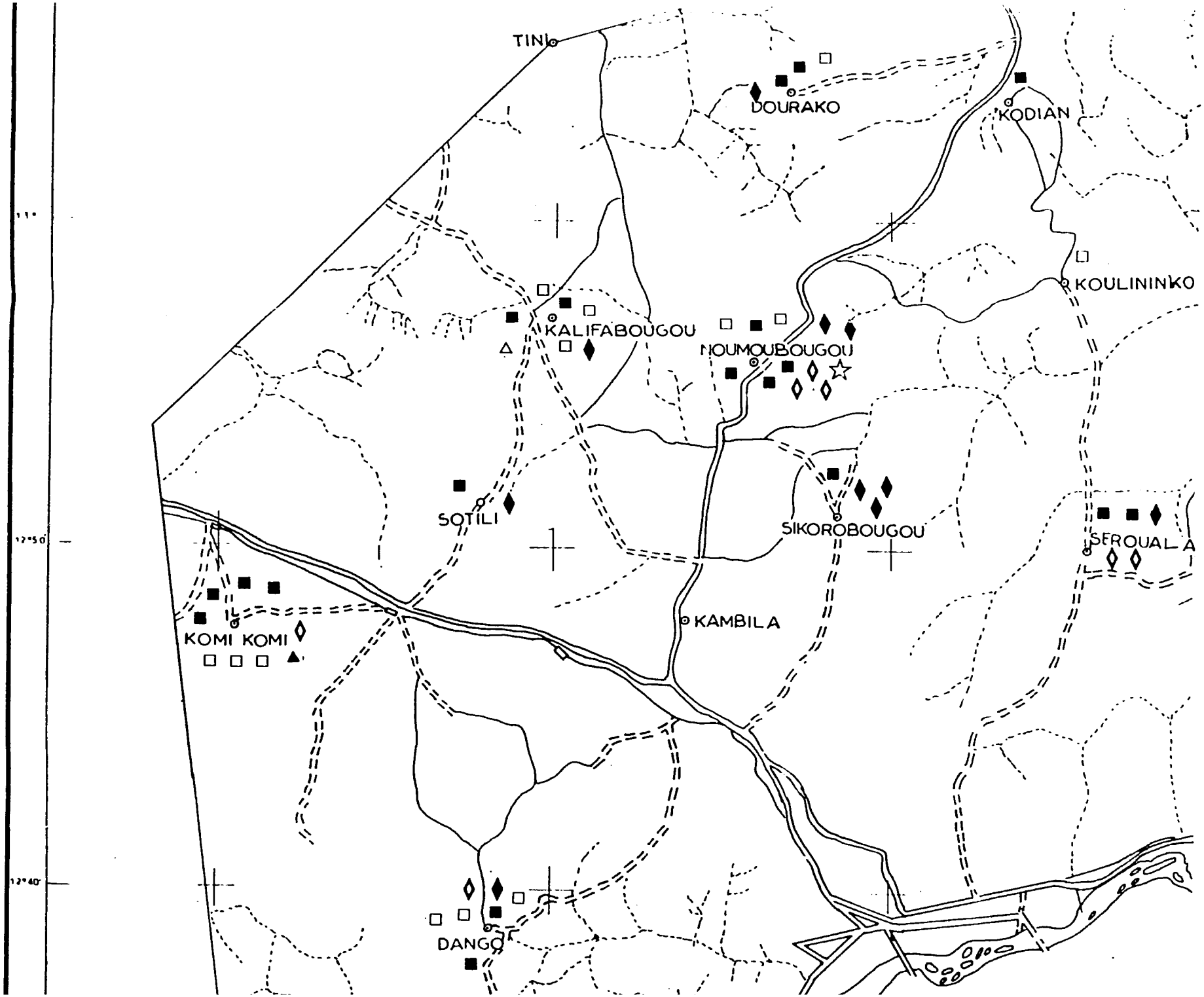
FIG 6

BOVINE TRYPANOSOMIASIS (TRYPANOSOMIASE BOVINE)

DISTRIBUTION OF TRYPANOSOME SPECIES
(DISTRIBUTION DES ESPECES DE TRYPANOSMES)

NORTH WESTERN SECTOR (SECTEUR DU NORD OUEST)

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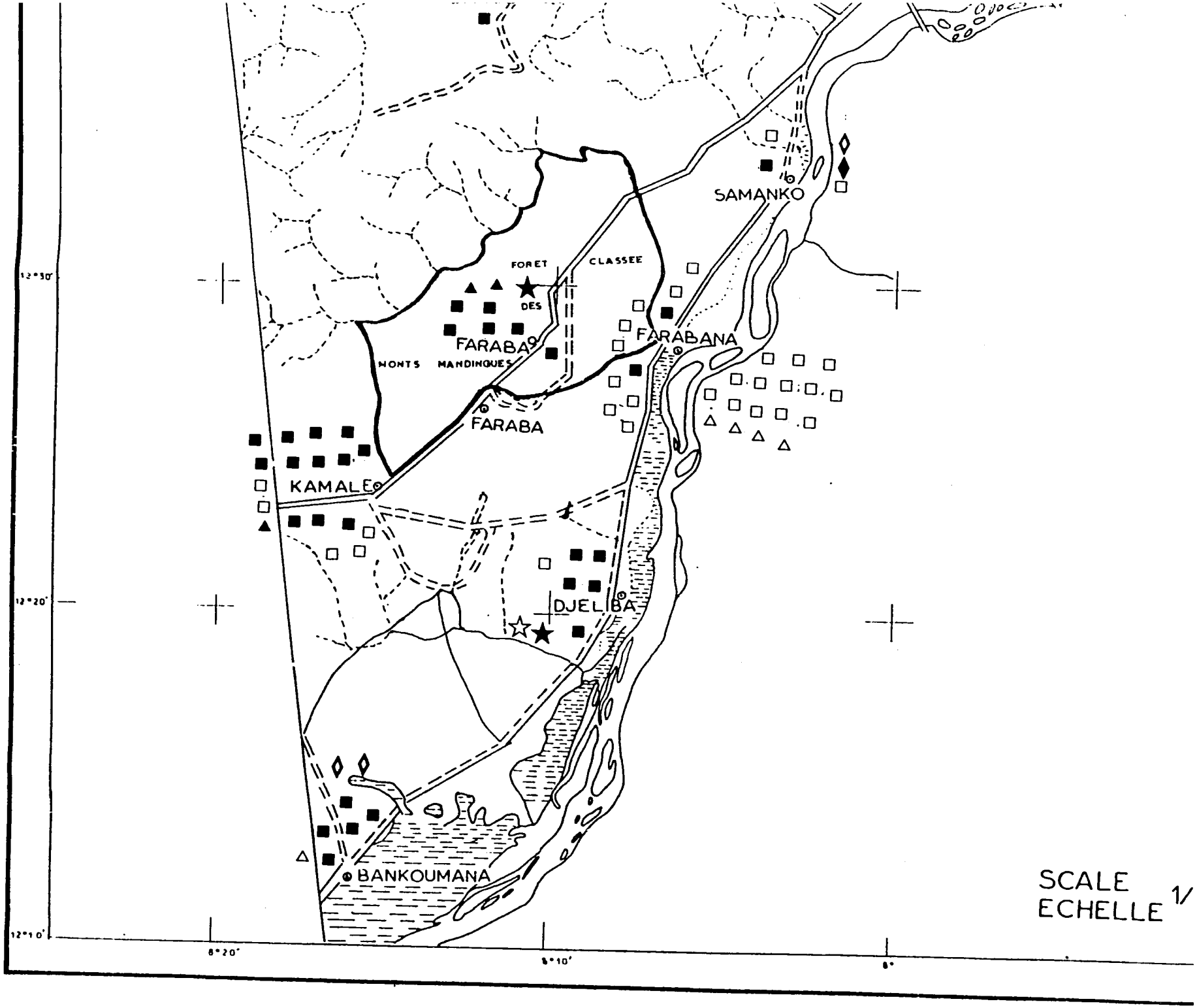
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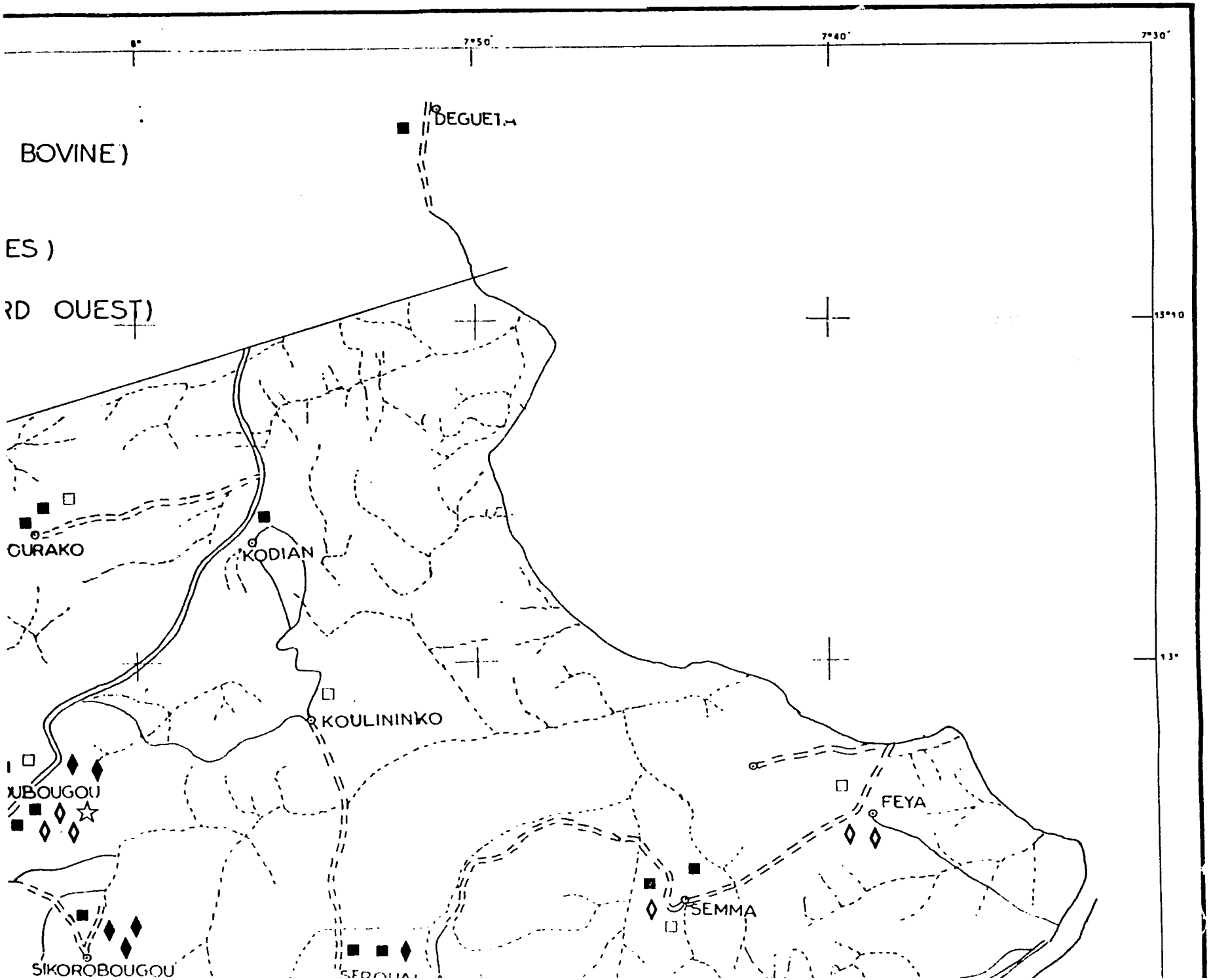
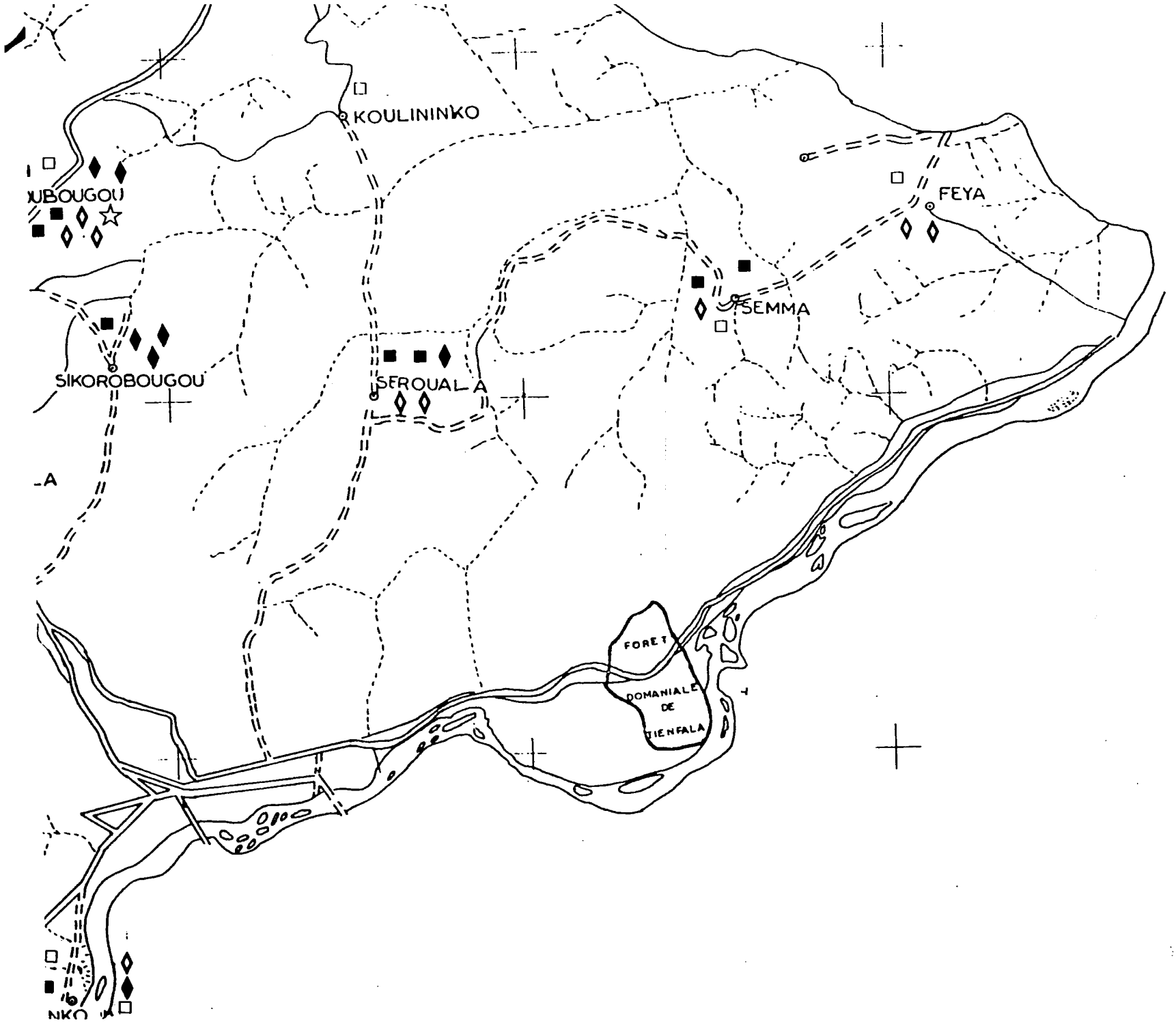
12°10'
8°20'
8°10'
8°
SCALE
ECHELLE 1/


7°50'
7°40'
7°30'
BOVINE)
ES)
RD OUEST)
DEGUETA
OURAKO
KODIAN
KOULININKO
UBOUGOU
FEYA
SEMMA
SIKOROBOUGOU


KOULININKO
FEYA
SEMMA
SIKOROBOUGOU
SFROUALA
FORET
DOMANIALE
DE
TIENFALA

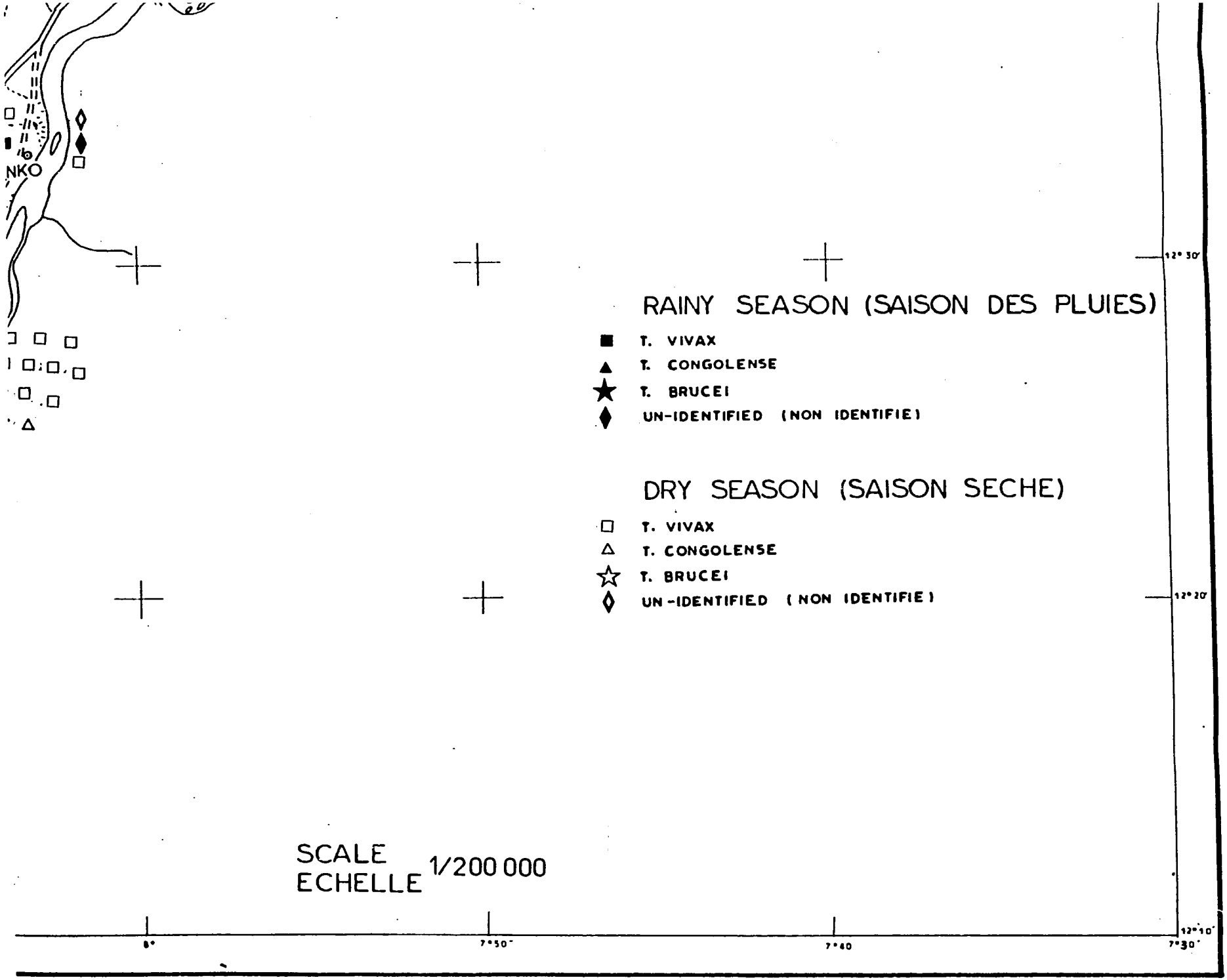
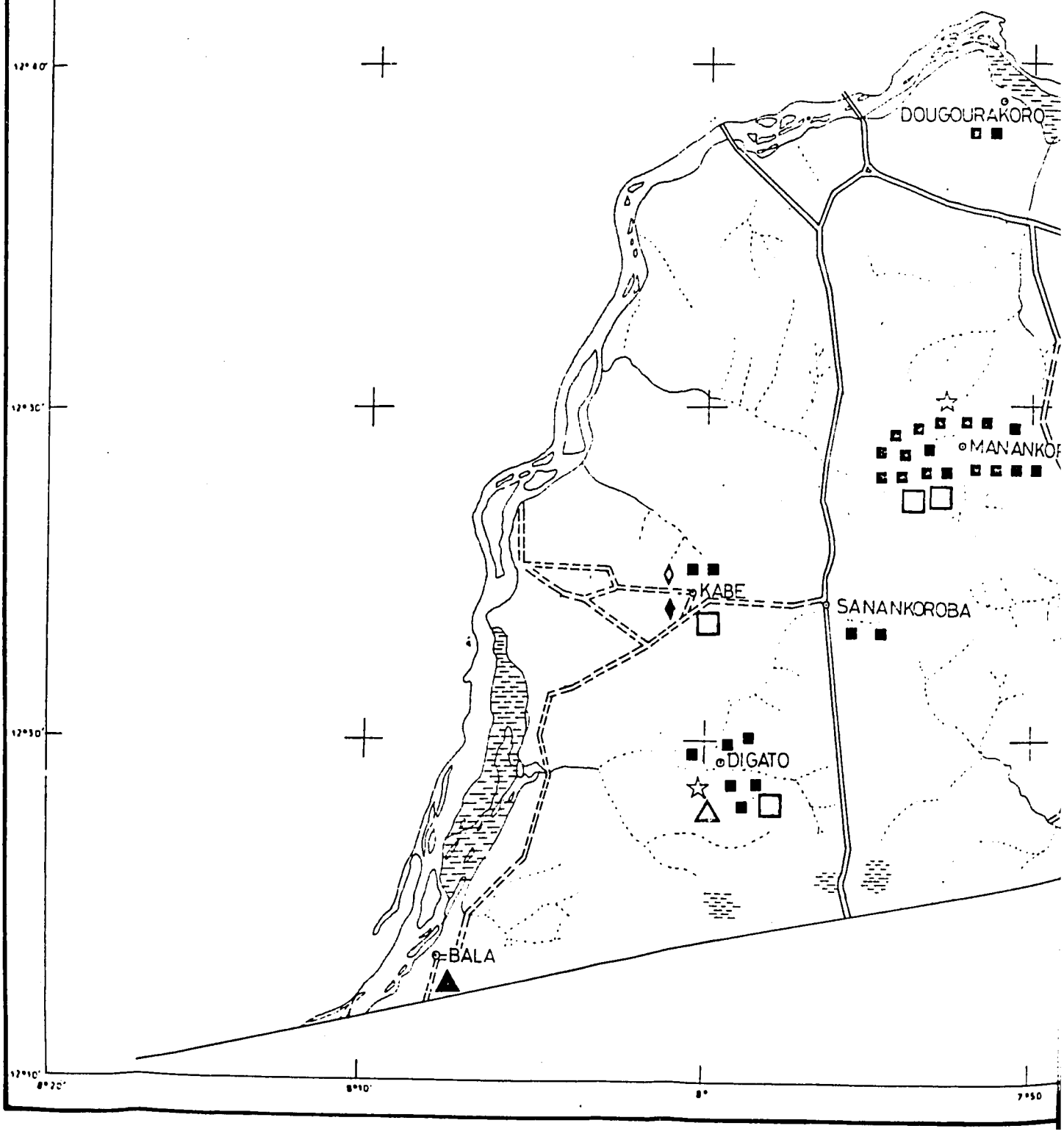

NKO
RAINY SEASON (SAISON DES PLUIES)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON IDENTIFIE)
DRY SEASON (SAISON SECHE)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON IDENTIFIE)
SCALE
ECHELLE 1/200 000
12° 30'
12° 20'
12° 10'
8°
7° 50'
7° 40
7° 30'

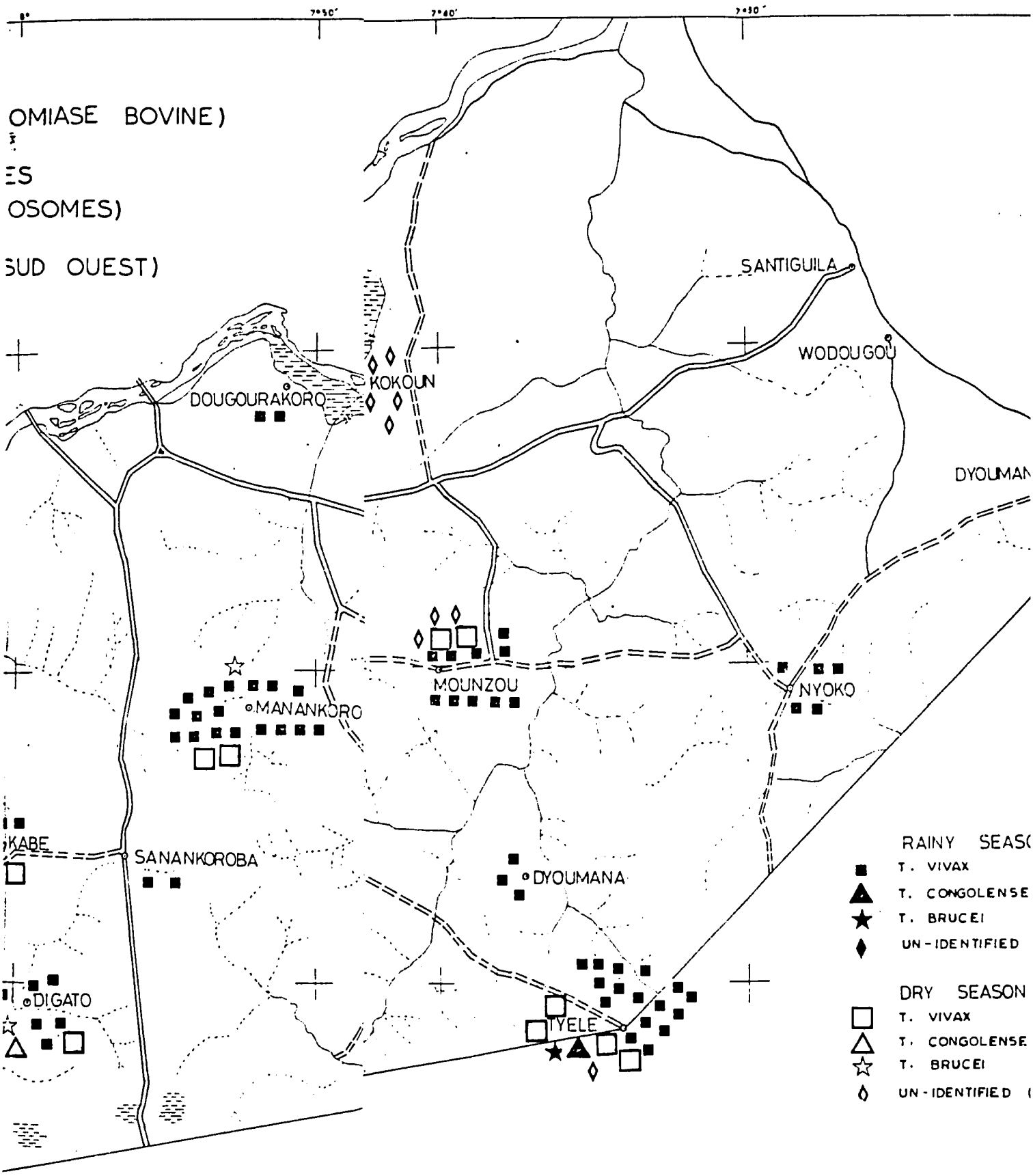
FIG 7

BOVINE TRYPANOSOMIASIS (TRYPANOSOMIASE BOVINE)

DISTRIBUTION OF TRYPANOSOME SPECIES
(DISTRIBUTION DES ESPECES DE TRYPANOSOMES)

SOUTH-WESTERN SECTOR (SECTEUR SUD OUEST)





SCALE
ECHELLE 1/200 000

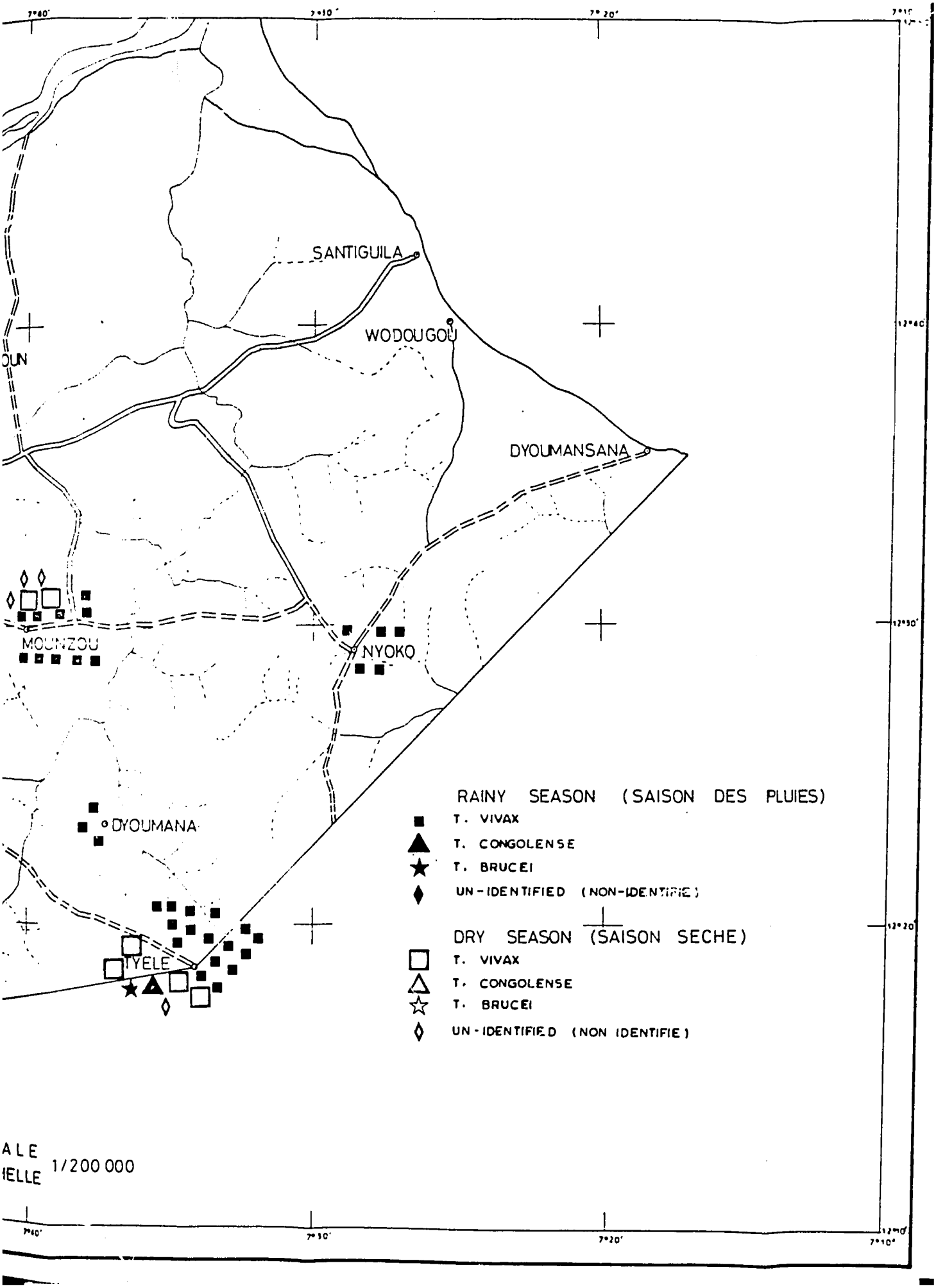
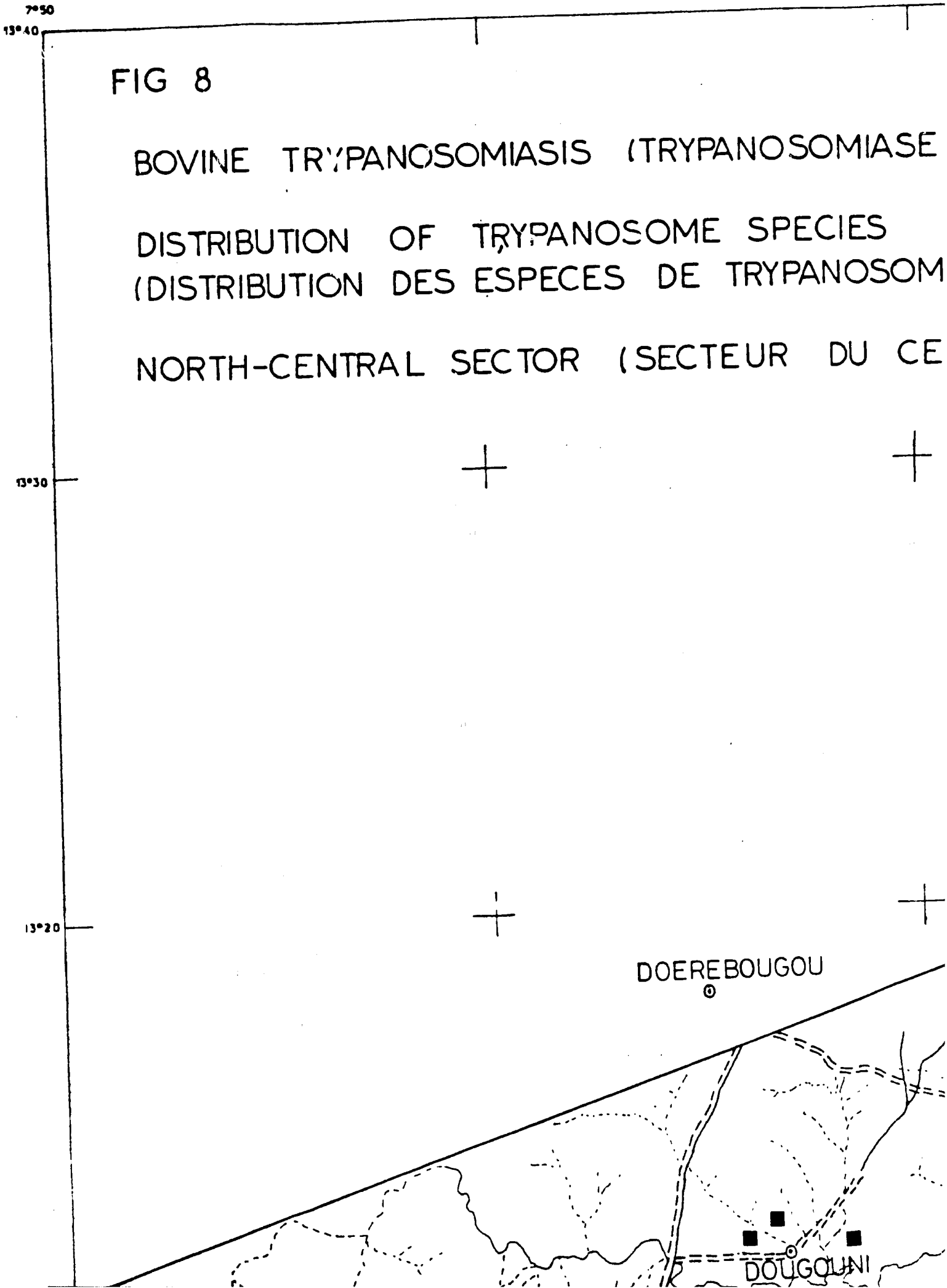

SANTIGUILA
WODOUGOU
DYOUMANSANA
MOUNZOU
NYOKO
DYOUMANA
TYELE
RAINY SEASON (SAISON DES PLUIES)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON-IDENTIFIE)
DRY SEASON (SAISON SECHE)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON IDENTIFIE)
ALE
IELLE
1/200 000

FIG 8

BOVINE TRYPANOSOMIASIS (TRYPANOSOMIASE

DISTRIBUTION OF TRYPANOSOME SPECIES
(DISTRIBUTION DES ESPECES DE TRYPANOSOM

NORTH-CENTRAL SECTOR (SECTEUR DU CE

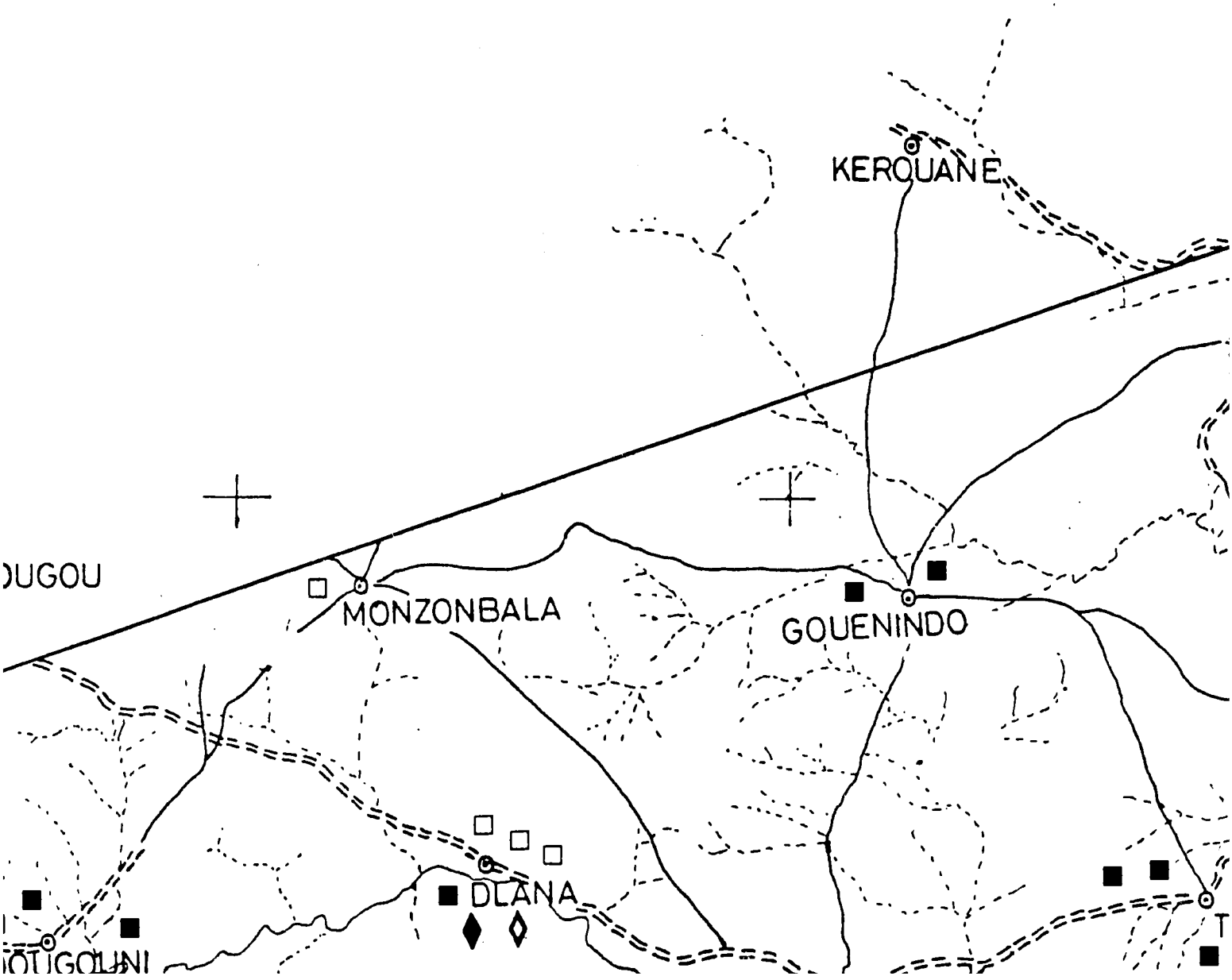


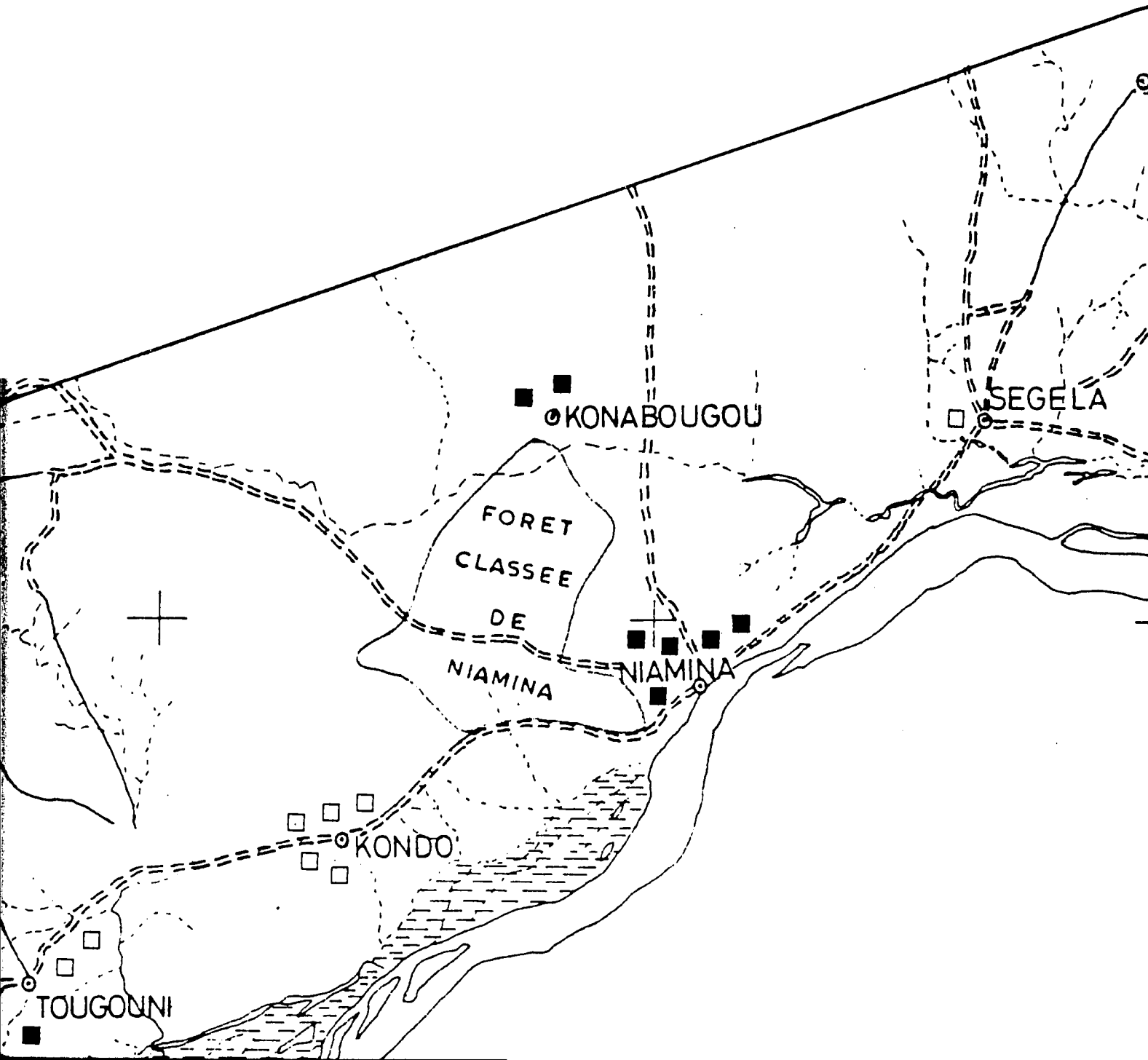
7° 30 7° 20

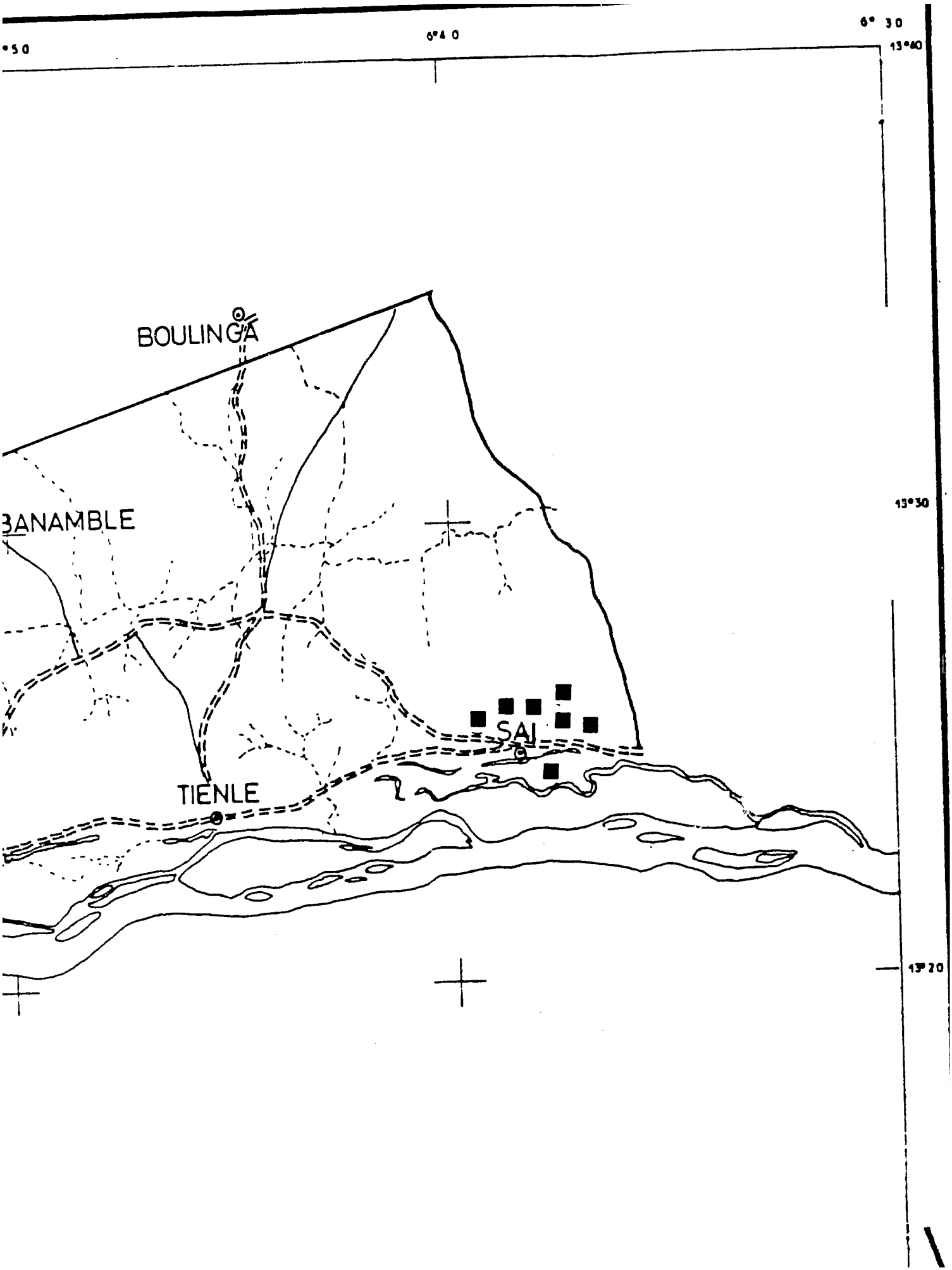
ANOSOMIASE BOVINE)

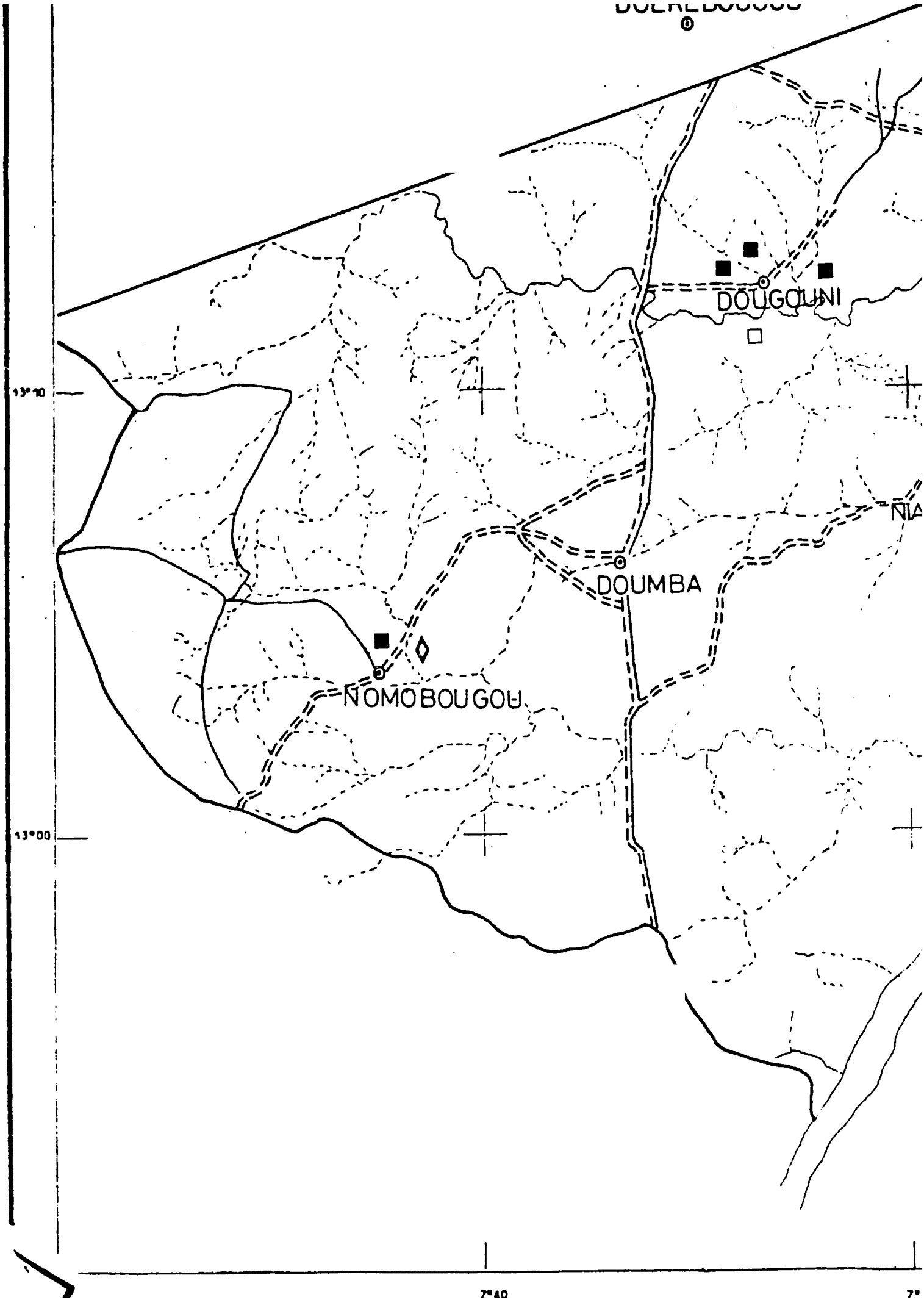
SPECIES
TRYPANOSOMES)

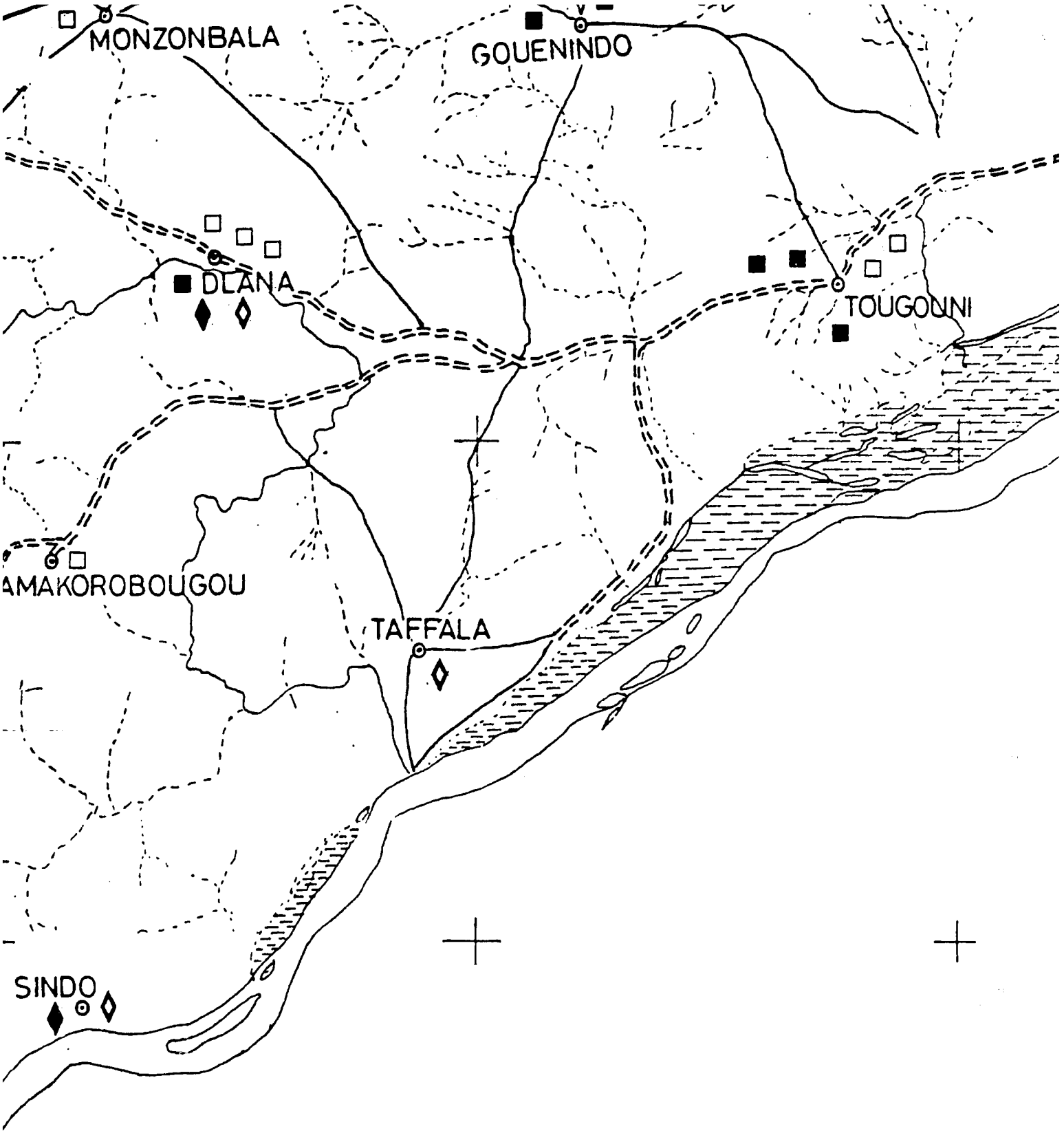
EUR DU CENTRE NORD)



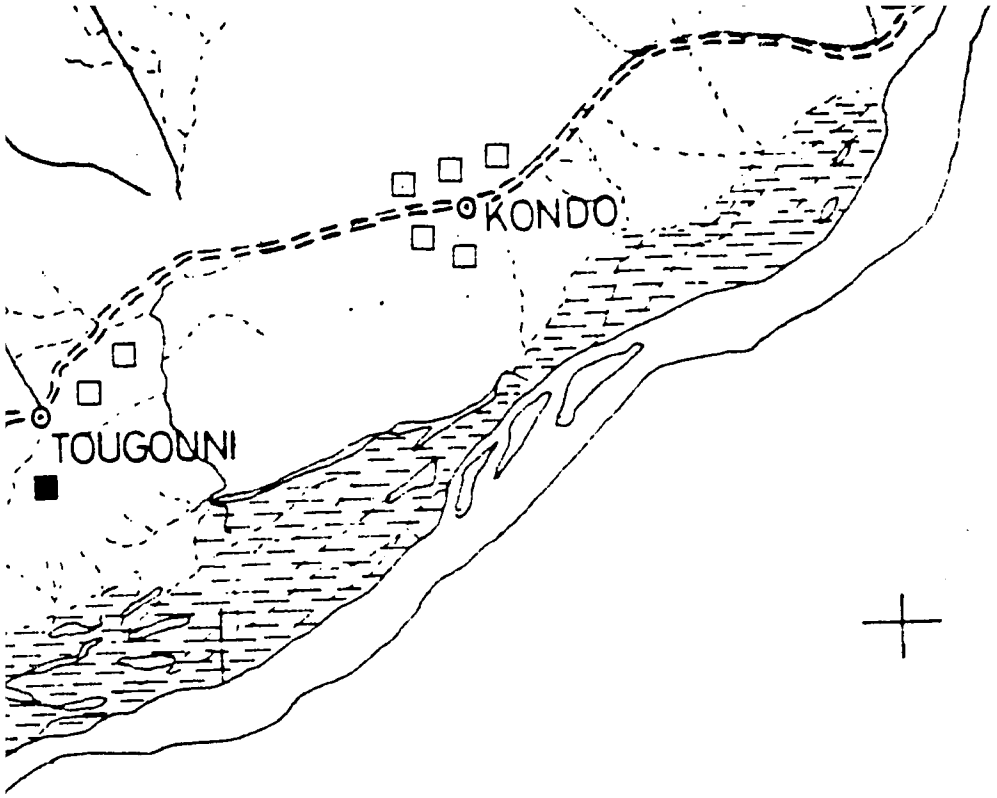

KONABOUGOU
SEGELA
FORET
CLASSEE
DE
NIAMINA
NIAMINA
KONDO
TOUGOUNI


6° 3 0
6°4 0
13°30
13°20
BOULINGA
BANAMBLE
SAI
TIENLE


DOUGOUNI
DOUMBA
NOMOBOUGOU
13°10
13°00
7°40
7°



SCALE
ECHELLE 1/200



SCALE
ECHELLE 1/200 000

RAINY SEASON (SAISON DES PLUIES)

■ T. VIVAX

▲ T. CONGOLENSE

★ T. BRUCEI

♦ UN-IDENTIFIED (NON IDENTIFIE)

DRY SEASON (SAISON SECHE)

□ T. VIVAX

△ T. CONGOLENSE

☆ T. BRUCEI

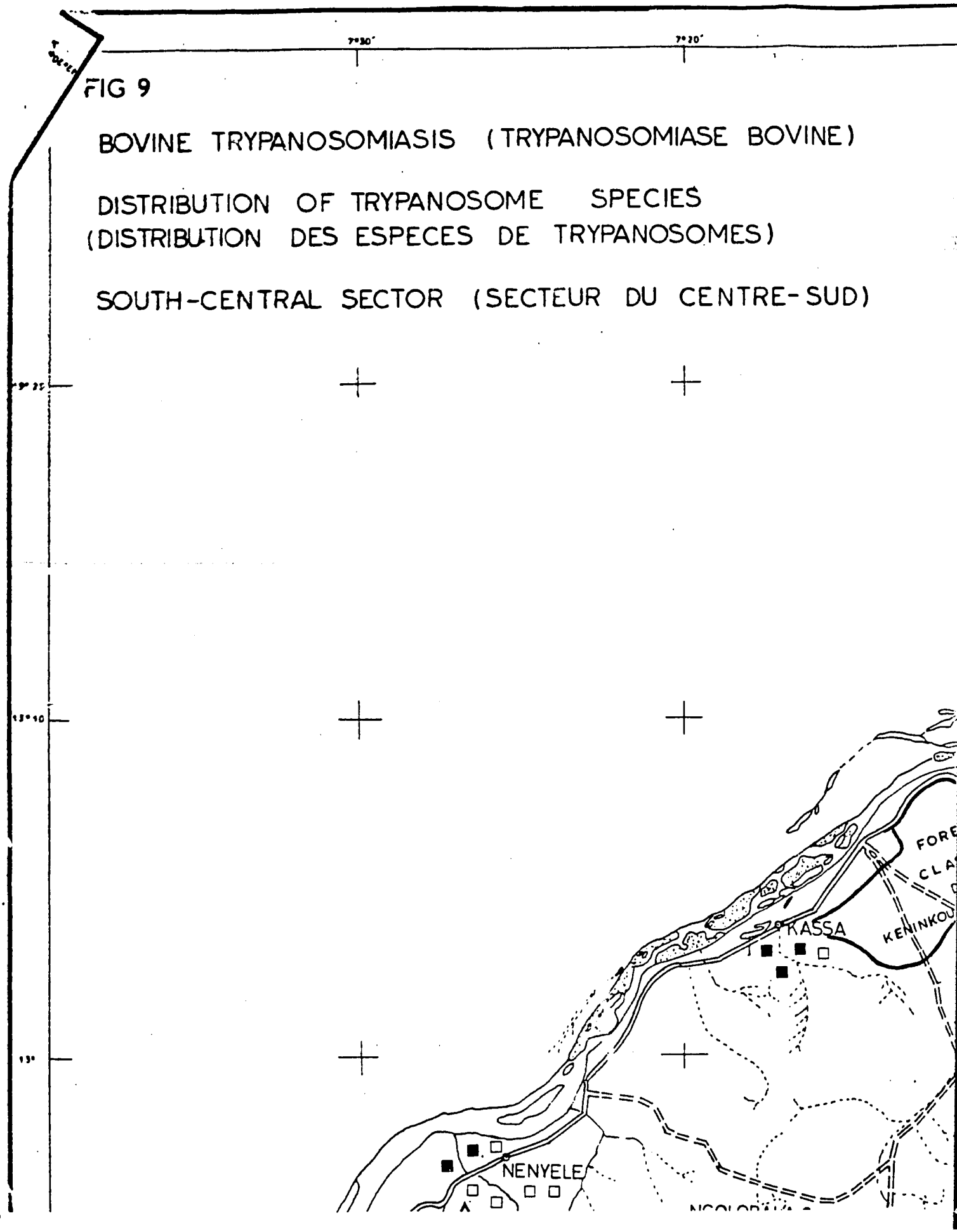
◊ UN-IDENTIFIED (NON IDENTIFIE)

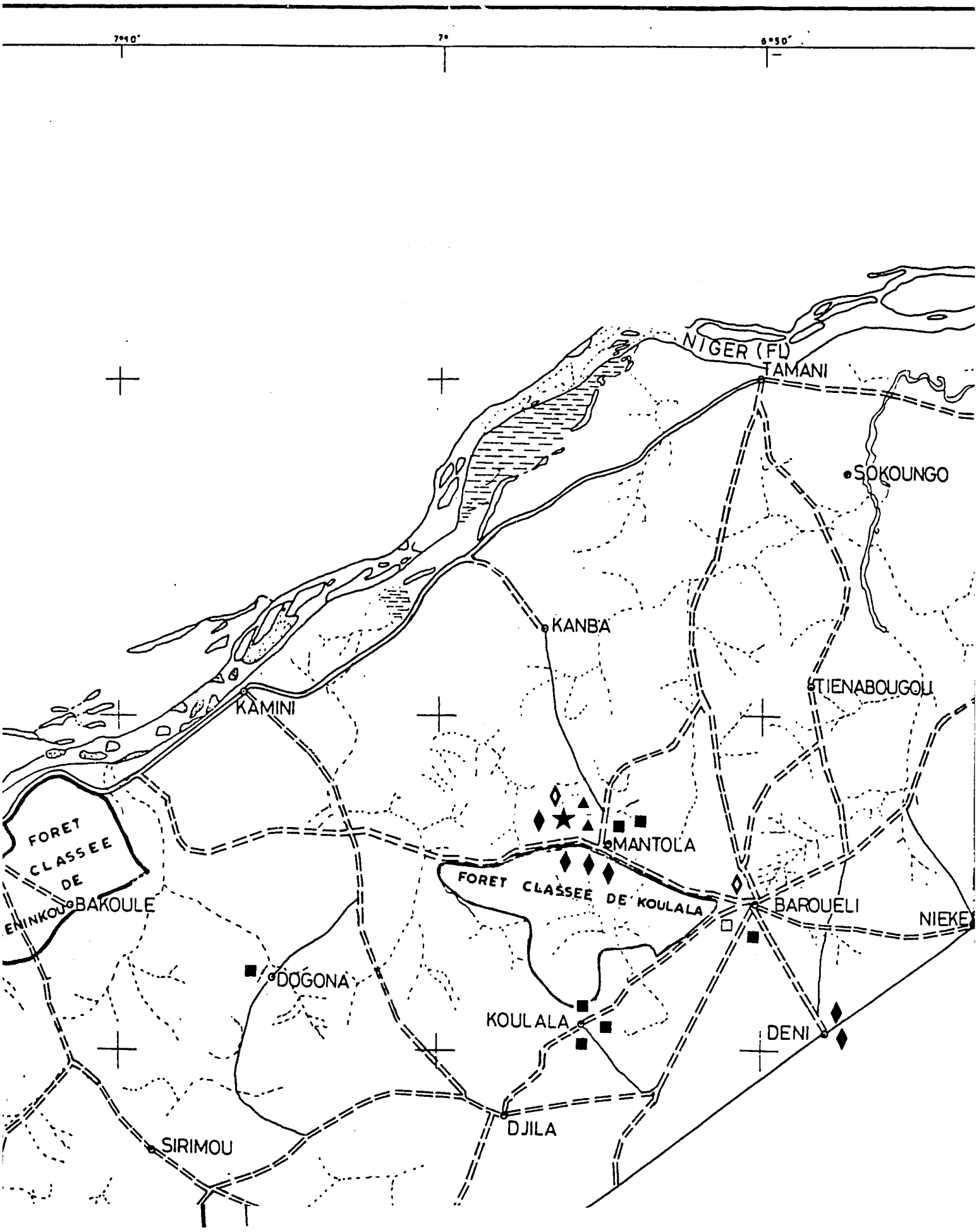
FIG 9

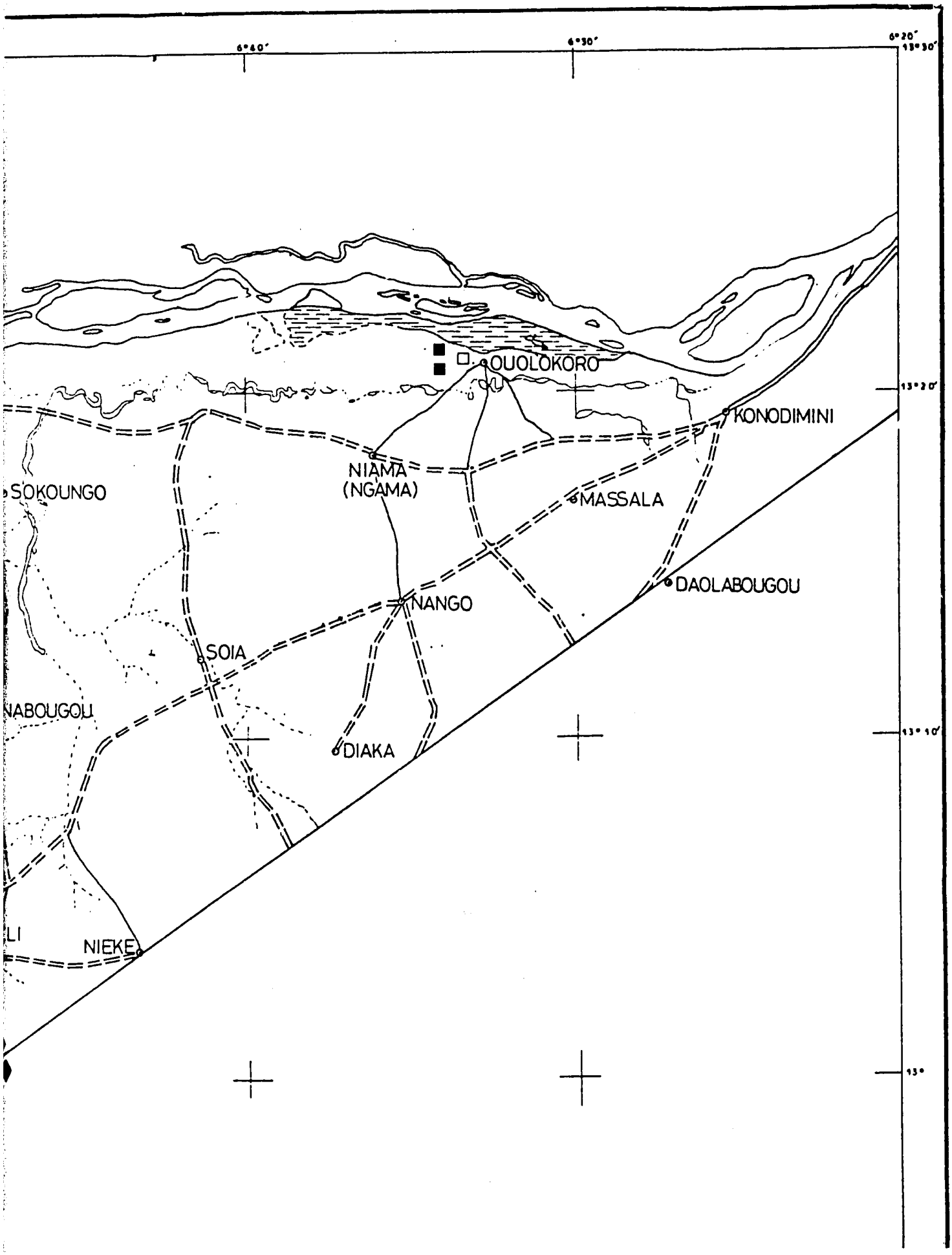
BOVINE TRYPANOSOMIASIS (TRYPANOSOMIASE BOVINE)

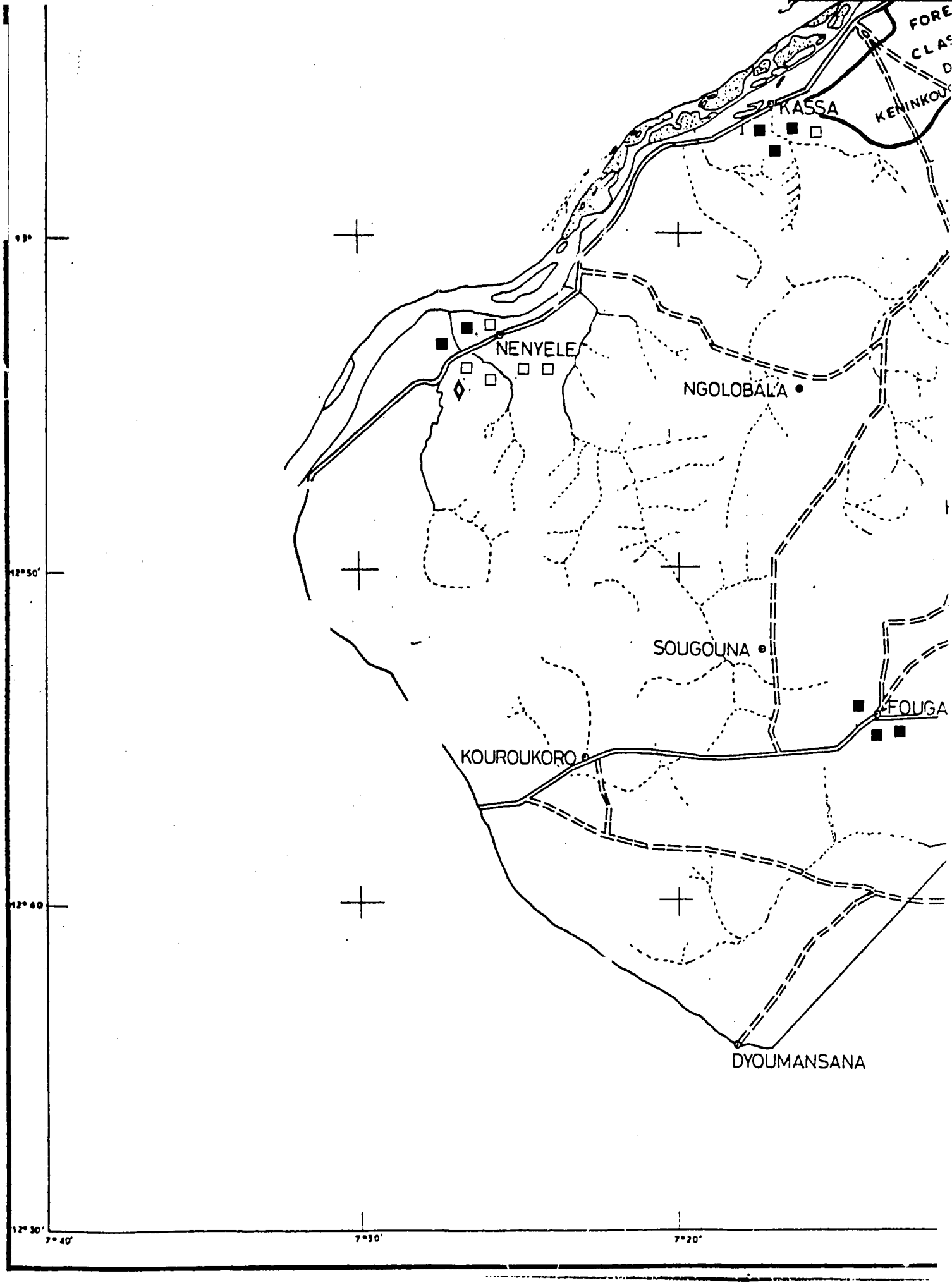
DISTRIBUTION OF TRYPANOSOME SPECIES
(DISTRIBUTION DES ESPECES DE TRYPANOSOMES)

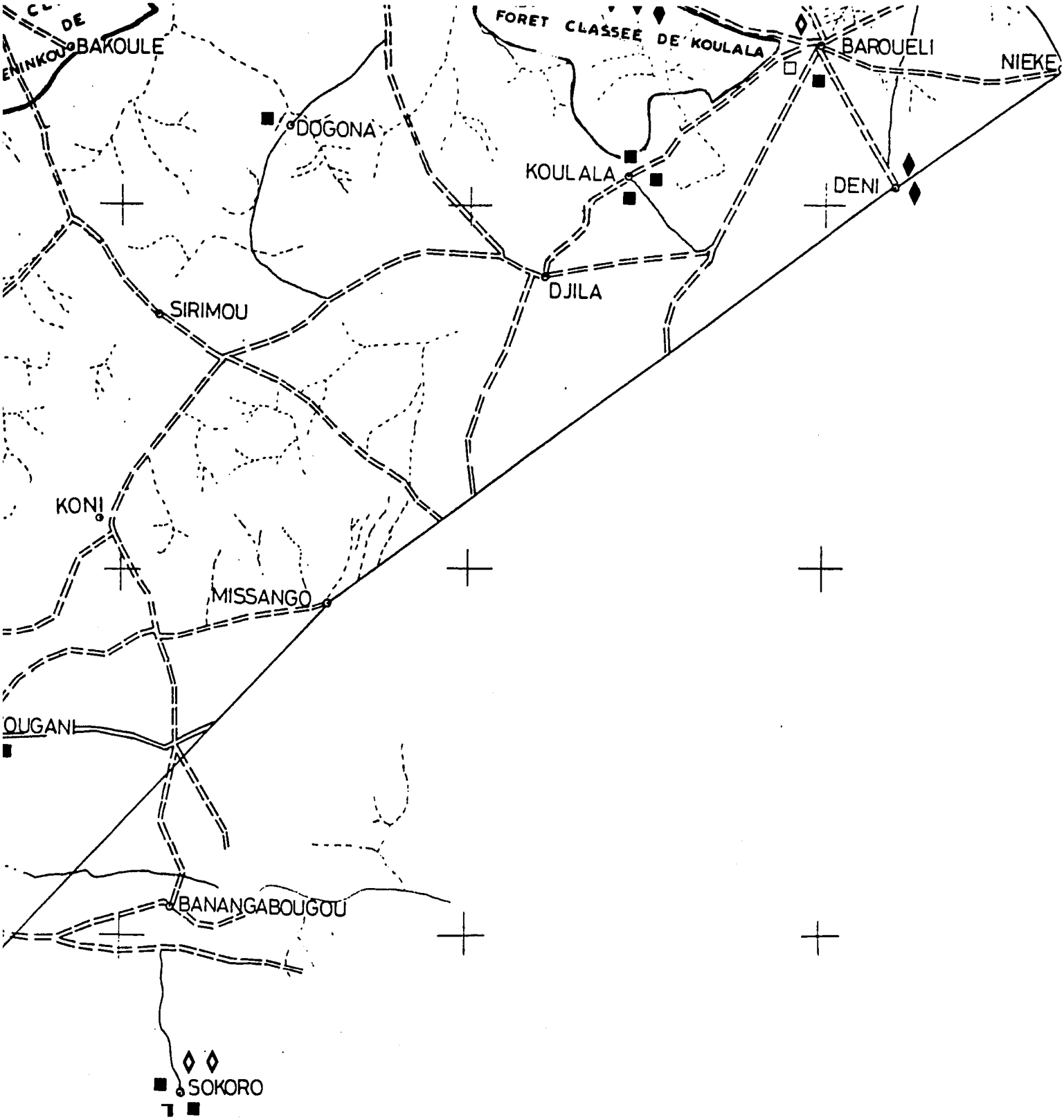
SOUTH-CENTRAL SECTOR (SECTEUR DU CENTRE-SUD)




7°10'
7°
6°50'
NIGER (FL)
TAMANI
SOKOUNGO
KANBA
TIENABOUGOU
KAMINI
FORET CLASSEE DE ENINKOU
BAKOULE
MANTOLA
FORET CLASSEE DE KOULALA
BAROUELI
NIEKE
DOGONA
KOULALA
DENI
DJILA
SIRIMOU

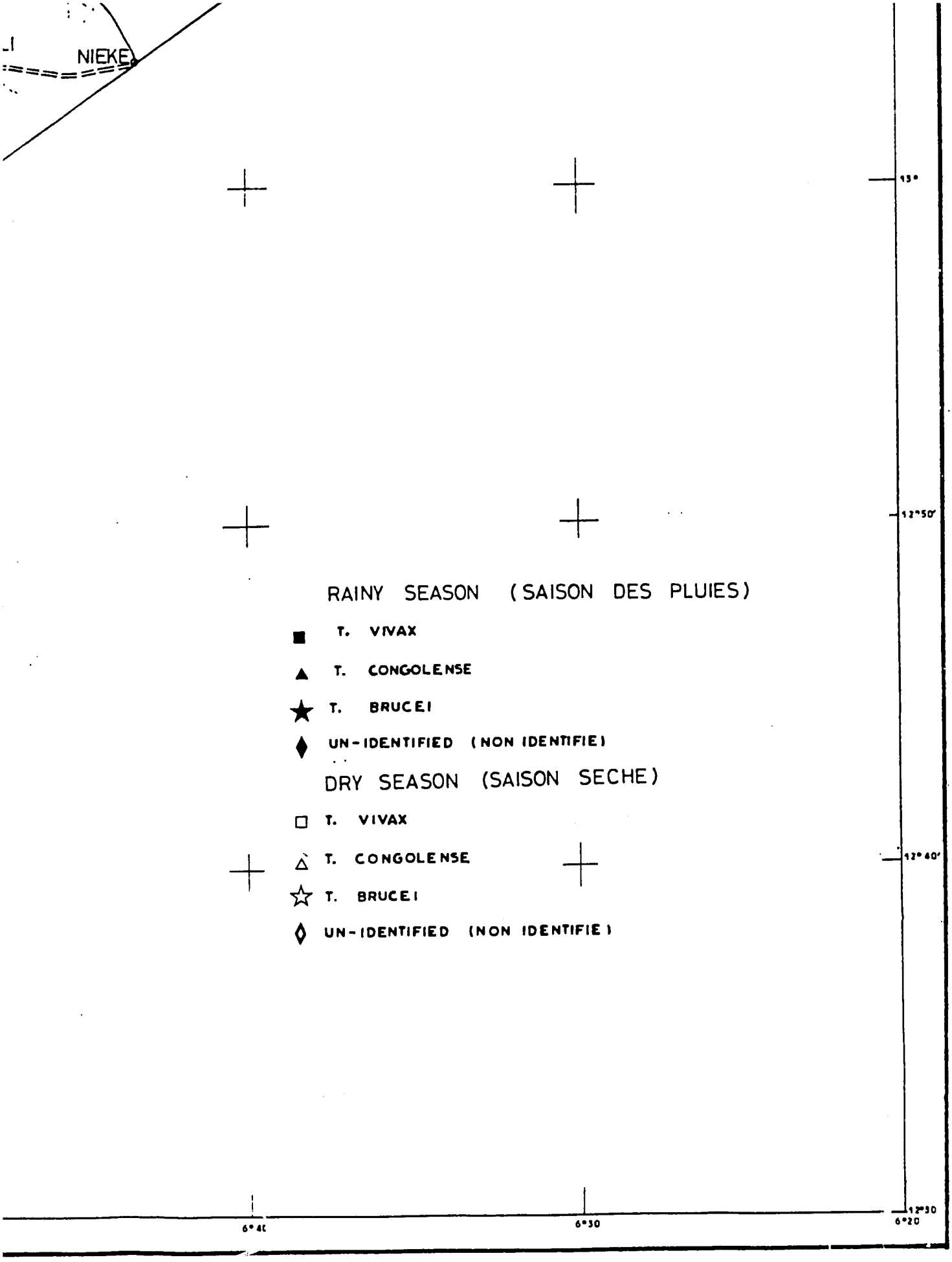

6°40'
6°30'
6°20'
13°30'
13°20'
13°10'
13°
OUOLOKORO
KONODIMINI
NIAMA
(NGAMA)
SOKOUNGO
MASSALA
DAOLABOUGOU
NANGO
SOIA
NABOUGOU
DIAKA
LI
NIEKE


FORE
CLAS
D
KENINKOU
KASSA
NENYELE
NGOLOBALA
SOUGOUNA
FOUGA
KOUROUKORO
DYOUMANSANA
13°
12°50'
12°40
12°30'
7°40'
7°30'
7°20'



SCALE
ECHELLE 1/200 000

7°10 7° 6°50


NIEKE
13°
12°50'
12°40'
12°30
6°40
6°30
6°20
RAINY SEASON (SAISON DES PLUIES)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON IDENTIFIE)
DRY SEASON (SAISON SECHE)
T. VIVAX
T. CONGOLENSE
T. BRUCEI
UN-IDENTIFIED (NON IDENTIFIE)