THE EFFECTS OF DELTAMETHRIN 'POUR ON' CONTROL TECHNIQUE ON GLOSSINA PALLIDIPES AUSTEN POPULATION STRUCTURE AND INCIDENCE OF TRYPANOSOMIASIS IN CATTLE.

BY

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Declaration

This Thesis is my original work and has not been presented for a degree in any other University.

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This Thesis has been submitted for examination with our approval as Supervisors

Dr. L.W. Irungu — Date 24/2/93

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Dedication

Dedicated to

My Husband Muthumbi Waweru,

and my Son Waweru Muthumbi,

for all the support you have given me.

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Table of contents.

Chapter Three: Incidence of trypanosomiasis in cattle

Chapter Four : General discussion and conclusion

List of Figures

Figure

List of tables

Table

List of plates

Plate

Abstract

A field trial was carried out in Galana ranch to assess the use of deltamethrin 'pour on' technique for the control of *Glossina pallidipes*. In Dakabuku (experimental area) 1167 Orma Boran steers were kept and treated with the insecticide (deltamethrin) every two weeks. Fly suppression was monitored using biconical traps baited with acetone and phenols. Incidence of trypanosomiasis in cattle was monitored every week by haematocrit centrifugation technique and Buffy Coat Examination (Murray *et al* 1977). The Packed Cell Volume (PCV) of cattle were measured and the infecting trypanosome species identified by their morphology and mortility. In Kapangani (control area) which is 10 Km away, 100 Boran steers were kept and the trypanosomiasis incidence in cattle and tsetse population density were monitored in a similar way.

In Dakabuku, fly population density declined from a mean of 350 fly/trap/day (f/t/d) to less than 10 f/t/d by the end of the study period. The berenil index in cattle in Dakabuku was also low (less than 2% and sometimes 0 by the end of the study period) compared to that of cattle in Kapangani which was high throughout the study period (between 4% and 12%). However, trypanosome infection rates in tsetse in the two areas were not significantly different (2.50% and 2.70% in Dakabuku and Kapangani respectively). In Dakabuku the average age of female tsetse was higher than in Kapangani for most of the study period; which may explain the lack of a significant difference in the trypanosome infection rates.

By the end of the study period tsetse challenge in Dakabuku was much lower than in Kapangani as a result of low population density of tsetse. This led to a low trypanosome transmission rate in cattle in that area (Dakabuku) and hence the low incidence of trypanosomiasis in cattle.

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The African trypanosomiasis is a disease of both humans and animals. The causative agent is a protozoan parasite of the class Zoomastigophora and order Kinetoplastida. The genus *Trypanosoma* has several subgenera and species (Hoare, 1964), all of which are vector transmitted either cyclically or mechanically, except *T. equiperdum* which causes dourine in camels and is transmitted through coitus. *Trypanosoma brucei gambiense* the causative agent of the human disease (sleeping sickness) and *T.b.brucei* the causative agent of the animal disease (nagana) are cyclically transmitted by tsetse (*Glossina*). Similarly, *T.vivax* and *T. congolense* cause nagana in cattle and are cyclically transmitted by tsetse. *T.simiae*, a parasite of suids, is transmitted by tsetse cyclically. *T. evansi* causes surra in camels and it is mechanically transmitted by biting flies such as *Hippobosca*, *Stomoxys*, and *Tabanus* and may not involve tsetse at all (Oyieke, 1987).

Trypanosomiasis is one of the health problems hindering economic development in tropical Africa where agriculture is the main source of income. The risks and consequences of animal trypanosomiasis are greater than human trypanosomiasis in terms of loss and cost. In tsetse free areas there is overgrazing and consequent deterioration of the land leading to low agricultural efficiency. On the other hand, in areas where animals are totally excluded due to tsetse infestation, low traction power, lack of manure and cash income are experienced (Cavalli-Sforza, 1987).

The disease renders uninhabitable ten million square kilometres of Africa's most fertile and resourceful land (Poli and Rognoni, 1987). Poli and Rognoni (1987) also estimated that a total of

three million animals die every year due to trypanosomiasis, thus hindering livestock and rural development in general (Tacher *et al*, 1988). In Kenya, trypanosomiasis spreads from coast to western Kenya. There are foci of the disease in Ukunda, Kilifi and Lamu in the coast province. Other foci are found in Lambwe Valley in South Nyanza, Nguruman and Masai Mara in the Rift Valley.

Livestock performance is greatly affected by trypanosomiasis as can be seen in increased life weight gains (Maloo *et al*, 1988; Defly, *et al*, 1988; Jeannin *et al*, 1988) and improved cattle productivity, with reduced abortions and calf mortalities (Mawuena and Yacnambe, 1988) in trypanosomiasis controlled areas. Under ordinary circumstances, Africa's livestock production in kilograms (meat) per head is much less than that of the developed countries, although her animal per caput ratio is much greater. There is also underproduction of milk and other dairy products compared to demand (Jahnke *et al*, 1988).

The disease in both humans and animals is characterized by an acute crisis in which anaemia and high levels of parasitaemia are experienced (Anosa, 1988). Anaemia results from destruction of erythrocytes (Anosa, 1988; Suliman and Feldman, 1989) by a mononuclear phagocytic system (MPS) (Murray and Dexter, 1988). Levels of anaemia were found to have a significant correlation with levels of parasitaemia in the host (Opasina, 1985) and this could be estimated by the packed cell volume (PCV) and the red cell count (Agu and Bajeh, 1987); PCV is therefore a useful indicator of levels of parasitaemia (Feron *et al*, 1988; Maehl *et al*, 1988 and Maloo *et al*, 1988) and livestock performance (Defly *et al*, 1988a).

The seriousness of animal trypanosomiasis depends on the parasite (species, strain, virulence) and the host (physiological status, nutritional status and the animal breed) (Murray and Dexter, 1988). For instance some *T.vivax* strains cause a haemorrhagic syndrome in cattle (Dirie *et al*, 1988; Olubayo and Mugera, 1987), sometimes associated with bleeding of the pinae. Some highly virulent *T.congolense* clones cause high levels of parasitaemia and finally death of the host (Joshua, 1990).

1.1.1 The life cycle of trypanosome

The life cycle of trypanosomes involves a continuously multiplying phase in the vertebrate blood and body fluids in the form of trypomastigotes. The trypomastigotes are ingested by tsetse during a blood meal. Development of cyclical species of trypanosomes takes place in the tsetse gut and mouth parts. There is multiplication of parasites in the midgut before they penetrate into the peritrophic membrane (Ellis and Maudlin, 1985) and enter the midgut cells (Ellis *et al*, 1985) then migrate forward into the mouth parts. In *T. brucei,* the final stage of development takes place in the salivary glands and infective metacyclic forms are injected into the proboscis with saliva during a blood meal. *T. congolense* completes its development in the proboscis (labrum and hypopharynx) while development of *T.vivax* takes place in the proboscis only. The infective forms of the three species can be seen in the proboscis in 12-35 days after an infective blood meal.

Completion of development and successful transmission of the trypanosome to the next host depends on a number of factors. Lambrecht (1980) reviewed these factors under the following headings; physiology of the parasite, physiology of the vector, ecology of the vector, feeding habits of the vector, physiology and behavior of the vertebrate host. The age of the vector at the time of infective blood meal is a crucial factor in the cyclical development of *T.brucei*. In most tsetse species it has been found that *T. brucei* infection establishes well when the first blood meal is infective and less so as the fly becomes older (Jordan, 1976). It is therefore possible to prevent transmission of trypanosomes by interfering with either of the three interacting components; that is the parasite development, the vector or the vertebrate host (Saint-Marc, 1987; Tacher *et al*, 1988).

1.1.2 Trypanosomiasis control

The consequences of trypanosomiasis in terms of loss and cost and the ever increasing human population makes trypanosomiasis control an imperative requirement in order to open up more land for utilization. For successful trypanosomiasis control, breaking up the epidemiological cycle is necessary. This could be achieved by either elimination of the parasite, elimination of the vectors from the environment, or interference with (livestock) the vertebrate host.

1.1.2a Use of trypanocides

The use of trypanocides attempts to control trypanosomiasis by interfering with the physiology of the host, and consequently interfering with the physiology of the parasite. In spite of the various problems such as development of resistant strains, this control method has met with some success. Improved cattle performance has been observed where cattle are maintained on trypanocides (Paling *et al*, 1987; Maloo *et al*, 1988; Fluck and Hopkins, 1988; Mbwambo *et al*, 1988).

The trypanocides used are either prophylactic (protective) or therapeutic (curative) in nature. Prophylactic drugs cure the existing infection and offer protection against further challenge for sometime while therapeutic trypanocides only cure the infection existing then and offer no protection thereafter. For instance Tribexin prosalts (quinapyramine sulphate and chloride)was observed to offer some protection against reinfection after cure of T.evansi infection in buffaloes and donkeys (Suryanenayana *et al* 1985; Bansal *et al* 1986 and Singh *et al* 1987)

For bovine trypanosomiasis the available drugs are homidium (ethidium and novidium), diminazene aceturate (berenil) and isometamidium chloride (samorin, trypamidium) (Ilemobande 1988). The three drugs can be used either for prophylactic or therapeutic purposes.

Essentially berenil is used as a therapeutic drug and clears trypanosomes from circulation within 24 hours (Njau *et al*, 1986; Moulton, 1986; Mawuena and Yacnambe, 1988). However liposomal berenil was found to offer protection against early reinfection with trypanosomes (Fluck and Hopkins, 1988). These two workers also compared the effect of both free and liposomal samorin and homidium and found that protection was offered by both drugs with a considerable variation.

Prothidium is purely prophylactic while samorin can be used for both prophylactic and therapeutic purposes. The International Laboratory for Research on Animal Diseases (ILRAD) (1987) and Peregrine *et al* (1987) have shown that treatment with samorin at a dose rate of 0.5 mg/kg body weight (bw) is both therapeutic and prophylactic. ILRAD (1987) found that samorin at a dose rate of 1.0 mg/kg bw gave protection to cattle against infection in a high challenge area for upto five months, while, using a single dose of 0.5 mg/kg bw protection was offered upto three months. In contrast, Njau *et al* (1986) found that a single dose of samorin (0.5 mg/kg bw) could give protection to cattle against infection for only six weeks.

Since trypanocidal drugs are essential in control of trypanosomiasis (Holmes and Torr, 1988), a strategic use of these drugs is suggested in order to reduce cost and at the same time maintain effectiveness. Such a strategic use of trypanocides (samorin and berenil) was made by Njogu *et al* (1986) in Galana where the total cost of drugs was reduced by 60% and still maintained effective protection. Mbwambo *et al* (1988) calls for judicious use of the two drugs (samorin and berenil) as they are the only sanative pair available for the treatment of bovine trypanosomiasis.

Samorin was found to have no effect on the reproductive performance of the tsetse but it interferes with trypanosome development in tsetse, thereby blocking transmission (Moloo and Kamunya, 1987; Agu, 1985). A samorin treated blood meal should therefore be given to sterile tsetse prior to their release to ensure interference with any trypanosome transmission (Moloo and Kamunya, 1987) during control using Sterile Insect Technique.

Use of trypanocides alone as a control method for trypanosomiasis is uneconomical and not possible (Heath and Heath, 1988). Besides, presence of reservoir hosts (wild game) make it impracticable to eradicate the parasite (Saint - Marc, 1987). The African game have an efficient method of controlling trypanosomes in their bodies which ensures selfcure and consequently survival of the host, (Mulla and Rickman 1988). When cattle and buffaloes were infected with trypanosomes either by bites of infected tsetse (Grootenhuis *et al* 1990) or by intravenous innoculation (Olubayo *et al* 1990), high levels of parasitaemia and anaemia were detected in cattle compared to buffaloes.

Other problems associated with use of trypanocides are development of resistant strains which was suggested to be as a result of underdosing with trypanocides (Gester, 1986). A multiple drug resistant *T.vivax* strain in Galana Ranch was reported by Schillinger and Rottcher (1986). The existence of the strain along the whole East African coast was confirmed by Schoenefield and Rottcher (1988). Berenil resistant *T.congolense* strains have been isolated from cattle in Tanzania (Mbambo *et al*, 1988).

Most trypanocidal drugs available are toxic to the host. In cattle sinefungin was found to cause 50% death (Zweygarth *et al*, 1986) and in camels, treatment of surra is limited by the low level of activity of most drugs which are highly toxic to the host (Schillinger and Rottcher, 1986). Localized tissue reaction has been observed at the point of administration of cymelarsan in camels (Tager-Kagan *et al*, 1989) and isometamidium chloride in cattle (Dowler *et al*, 1989).

Most drugs were developed long ago and thus have lost their effectiveness. For instance melarsoprol was developed some 40 years ago and is now associated with about 10 % failure rate due to resistance (Kazyumba *et al*, 1988). No new drugs are currently being developed because of cost of development and lack of market. Control of trypanosomiasis by trypanocides alone is therefore not possible and a judicious combination of all available methods (Saint-Marc, 1987) and use of simple control techniques (Finelle, 1987) is encouraged.

1.1.2b Vector control

Tsetse, the vectors of trypanosomiasis occupies ten million square kilometres of Africa's most fertile land (Poli and Rognoni, 1987) and this is about 40% of Tropical Africa (Jahnke *et al*, 1988). Tsetse distribution in Africa is patchy and spreads from sea level to about 1800m above sea level. There are twenty two different species known and broadly grouped into three categories. These are morsitans group, fusca group and palpalis group.

The morsitans group occupies the savannah vegetation and spreads from the forest edge to the dry semi desert regions. The group is made up of five species. The most important species as vectors of trypanosomiasis are *G. morsitans* and *G. pallidipes*. *G. morsitans* is common in the savannah region of East, Central and West Africa while *G. pallidipes* is common in savannah regions of East Africa only.

The fusca group is a forest dwelling group. The group is made up of twelve species of tsetse, all of which are large in size. These flies occupy the equatorial vegetation of West and Central Africa although *G. brevipalpis* and *G. longipennis* are found in secondary forests of East Africa. The group rarely feeds on man and thus only transmits animal trypanosomiasis. The most important vectors are *G. fusca*, *G. brevipalpis* and *G. longipennis*.

The palpalis group is a riverine dwelling group and occurs in forest vegetation growing near rivers. It is made up of five species of which *G. tachnoides* and *G. palpalis* are the most important vectors of trypanosomiasis. These flies occur in West and Central Africa and may extend to the Western areas of East Africa.

The life cycle of tsetse starts with an egg which hatches inside the female uterus to release the first instar larva three to four days after fertilization. Development of the other larval instars takes place inside the female uterus to release a third instar larva. The larva is deposited in a moist shaded place where it burrows immediately and becomes a pupa. The adult takes between seventeen to ninety days with an average of 35 days to emerge. Emergence depends on the environmental conditions especially temperature and humidity. The teneral flies emerge from the puparium and look for a blood meal, then mate after 2-3 days. A newly emerged female then deposits it's first larva 15-20 days after emergence.

In cyclical transmission of trypanosomes, the longevity of the adult fly is an important factor, the age of the fly at the time of infective blood meal is also important for some species of trypanosomes that have a complex life cycle in tsetse (Jordan, 1976). A fly should live long enough for trypanosomes to complete the developmental cycle after the infective feed. In trypanosomiasis control therefore, the aim is to reduce the number of adult flies that can transmit infection and reduce their longevity in order to interfere with the development and transmission of the trypanosomes (Rogers and Randolph, 1984).

1.1.2bi Enviromental modification

The oldest tsetse control methods involved destruction of their habitats and elimination of their food sources. Bush clearing was effective in reducing tsetse population density but it was not economical for large scale tsetse control. Kinyanjui (1983) was able to reduce the population of *G. fuscipes* along the lake Victoria shores. He reduced the fly numbers to 4 flies per week compared to 42 flies per week prior to control and the area remained free of tsetse for 16 weeks thereafter. In another tsetse control campaign, Wellde *et al* (1989) combined bush clearing and ground spraying with dieldrin and cypermethrin. This method was effective in reducing the prevalence of sleeping sickness which had earlier been unaffected by spraying with pyrethroids. Bush clearing is however not economically feasible because it has to be done each year thereby incurring expense. Elimination of wild game which serve as a food source for the tsetse and reservoir for infection was attempted in Uganda and Zimbabwe. The method is not very effective; besides, killing wild game is illegal.

1.1.2bii Control Using Insecticides

Before the discovery of synthetic insecticides at the beginning of this century, pest control depended on organic compounds extracted from plant materials. A review of the synthetic insecticides is given by Moriarty (1969). These are loosely classified into three; organochlorines such as Dichloro diphenyl trichloroethane (DDT), dieldrin and endosulfan; organophosphates such as malathion, fenithion and parathion and the carbamates such as carbaryl and propoxur.

When DDT was developed in 1939, all other control techniques were abandoned and DDT was seen as the panacea for pest control. For control of tsetse, ground spraying with pressurized knapsacks into the tsetse habitats is common. Jordan (1977) gives a review of tsetse control using

insecticides. Later on, investigations were mounted to come up with chemicals that could be used for large scale control by aerial application (Laird, 1977).

Synthetic insecticides may be persistent or nonpersistent in nature and this property determines the technique of application to control tsetse. Persistent insecticides for instance may be applied only once to last throughout the tsetse developmental cycle (Carle, 1985). On the other hand when nonpersistent insecticides are used, subsequent applications should be done before the new emergencies deposit their first larva, the interval between sprays being determined by environmental conditions such as temperature and humidity. In most aerial control programs, five applications are done with an interval of 16-23 days between sprays. The pupal developmental period has been found to be completed by the fourth application (Chapman, 1976; Davies, 1978; Laird, 1977).

DDT is the most extensively used synthetic insecticide and there are reports of death of fish in lake Kariba in Zimbabwe due to its cumulative effect after ground spraying. Dieldrin is another residual insecticide used in ground spraying (Mpofu, 1987). It is however limited by its high toxicity, though effective in tsetse control. For instance in Lambwe Valley, Kenya it was used as a ground spray and was able to check the prevalence of sleeping sickness (Wellde *et al*, 1989). For aerial spray ultra-low-volume (ULV) of endosulfan is used because it has minimum effect on non-target organisms (Allsopp, 1988). Endosulfan has been used in aerial sprays for large scale integrated tsetse control (Hursey *et al*, 1988; Lee and Torr, 1988) or where ground spraying has failed to control tsetse.

Aerial spraying, however is too expensive for routine tsetse control, it has been estimated to be twice as expensive as ground spraying with DDT (Mpofu, 1987) and it is unsuitable for areas with broken terrain (Lee and Torr, 1988). The less expensive insecticides have their limitations. Dieldrin for instance is too dangerous for the spraymen to handle (Mpofu, 1987) while DDT causes a marked environmental contamination.

Deltamethrin is a synthetic insecticide that has been used against vectors of endemic diseases such as mosquitoes with success. It is a thousand times more powerful than DDT and a hundred times more powerful than dieldrin and endosulfan. Furthermore deltamethrin can be used either as a residual or non-residual form. Ground spray with the residual form lasts throughout the pupal developmental period (Carle, 1985).

However, extensive ground spraying with deltamethrin is limited by cost. Even though deltamethrin can be used as a non-persistent insecticide, direct spraying into the environment will meet with objections from ecologists and environmental conservationists (Linear, 1985; Kemf, 1988). Besides, Everts and Koeman (1987) suggest that the ecological impact of non-persistent insecticides combined with increased human pressure on the environment may result in decreased resilience of many ecological ecosystems, thereby causing irreversible damage to these habitats. Thus the preferred method of chemical control of tsetse is use of insecticide impregnated traps and targets (Kemf,1988).

1.1.2biii Traps and Targets

A need to conserve the environment and yet control tsetse flies using insecticides has led to the development of traps and targets. The technique of trapping tsetse as a means of control was first used in the Principle Island in West Africa. Complete eradication of *G.p. palpalis* in the Island was achieved. The trapping technique was abandoned soon after the discovery of synthetic insecticides. It was revived in the early seventies when Challier developed the biconical trap (Vale *et al*, 1985). The trap was improved by Challier and Laveissiere (1973) for catching the riverine tsetse. Okoth

(1985) modified the trap and used indigenous plant materials such as bamboo poles and rattan cane to reduce the cost of construction. The trap catches were almost the same as those of the standard trap design. The biconical trap has since been used for the control of the riverine tsetse flies such as *G. palpalis* and *G. tachnoides* (Carle, 1985; Mpofu, 1987; Mawuena and Yacnambe, 1988; Allsopp, 1988). The biconical traps may also be used as barriers to stop re-invasion (Douati *et al*, 1986) or for monitoring tsetse flies prior to or during a control program (Owaga, 1989; Randolph *et al*,1989).

Other types of traps used in tsetse control and monitoring tsetse populations are the pyramidal and the monoconical traps. The efficiency of each trap design depends on the species of tsetse being trapped and the area. For instance Gouteux and Lancien (1986) found the pyramidal trap being used for trapping *G. palpalis* and *G. fuscipes* in Congo more efficient than the biconical trap. When the biconical trap was compared with the monoconical trap, the latter was more efficient than the former (Dagnogo and Gouteux, 1985).

The F series of traps is a new trap design developed in Zimbabwe (Flint 1985). The F3 trap was found to be the best for sampling *G.longipennis* (Kyorku *et al*, 1990). The Ngu trap based on Zimbabwe F3 trap was compared with the biconical trap. The former trap was more efficient for trapping *G. pallidipes* than the latter (Brightwell *et al*, 1987).

Targets have an advantage over traps for being simpler in design and are thus less expensive to construct. The screens or targets have been used successfully for control of riverine tsetse (Carle, 1985; Douati *et al*, 1986; Mpofu, 1987; Ethiopia Ministry, 1988 and Neil, 1987). They are also effective for both savannah dwelling and forest dwelling tsetse species (Laveissiere *et al*, 1987). For instance Opiyo *et al* (1990) achieved a 99.9% reduction of *G. pallidipes* population in both Galana and Lambwe Valley in Kenya after installation of targets. In integrated tsetse control programmes,

targets may be used as barriers to stop re-invasion (Merot *et al*, 1984; Ethiopia Ministry, 1988). A review of the development of traps and targets was given by Wall and Langley (1991).

The efficiency of traps and targets in tsetse control depends on the attractiveness (visual and olfactory) and the insecticides impregnated (class and concentration). Tsetse population that lands onto the targets depends on the fabric, size of thread and nature of weaving of the clothing material used (Laveissiere *et al*, 1987). Each proportion of the dye has a role in visual attractancy. The blue/black/blue colour design of nets is the most attractive colour combination (Laveissiere *et al*, 1987a; Ethiopian Ministry, 1988; Olumande *et al*, 1988). The blue colour attracts flies to the traps while the black colour stimulates them to land.

The discovery that tsetse flies respond to host odours has led to the baiting of traps and screens (Vale *et al*, 1985; Brightwell *et al*, 1987; Mpofu, 1987; Allsopp, 1988). Host derived substances such as urine (Owaga, 1985; Brightwell *et al*, 1987; Gough *et al*, 1988; Randolph *et al*, 1989) and skin secretion, sebum (Warnes, 1990) have been found to produce host odours attractive to tsetse flies. When trap catches in baited and unbaited traps were compared Randolph *et al* (1989) found that catches from the baited traps were more representative of the whole population than unbaited traps.

For the impregnation of traps and targets, deltamethrin has been used extensively (Merot *et al*, 1984; Carle, 1985; Douati *et al*, 1986; Neil, 1987; Allsopp, 1988). The advantage of deltamethrin over other insecticides is its applicability as a residual or non-residual form. Deltamethrin induces tsetse mortality by interfering with the physiological activities. When sublethal doses of the insecticide were topically applied to female tsetse (*G. palpalis*), it was found to inhibit larviposition, probably due to prolonged paralysis of uterine and larval muscles (Riordan 1987). In the pupa of the same

tsetse species, deltamethrin was found to cause failure of emergence. However, if a sub-lethal dose of deltamethrin was followed by treatment with an organochloride while the larva was still *in utero*, emergence occurred (Riordan, 1987a). In *G.m. morsitans*, Nitcheman *et al* (1988), found that sublethal doses of deltamethrin caused delay in feeding, abortion and larval clumping.

In field application deltamethrin remains active for a minimum of three months (Carle, 1985; Douati, 1986; Neil, 1987) after which reimpregnation with the insecticide is necessary. One main disadvantage of deltamethrin is its high rate of degradation by the ultraviolet (uv) component of the invisible spectrum. Attempts are being made to incorporate uv absorbers in the insecticide in order to increase it's field life.

Traps and targets are expensive to maintain in terms of labour input and finance. Reimpregnation with insecticides is required every three months while clearing the vegetation growth around the traps is done every few months depending on seasons. In addition the fabrics or clothing materials require replacement every year to maintain efficiency. There have been reports of loses of targets and traps either through theft or forest fires. Opiyo *et al* (1990) reported a loss of 11.8% of targets in Lambwe Valley through grass fires.

The alternative is use of animals as targets rather than the stationary traps and screens. The risk of loss of targets is minimized and flies are attracted to moving objects. Natural host odours will attract flies to land other than the artificial ones. Besides, only a few animals are required to cover a large area.

When small ear tags impregnated with permethrin were used on N'Dama cattle, negligible effect on tsetse was observed (Mayer and Denoulet, 1984). Similar eartags impregnated with 0.0046% deltamethrin and fixed onto oxen had a knockdown effect of 41% and mortality of only 16% on

tsetse (Thompson, 1987). When eartags are used, the insecticides do not spread to landing sites of the tsetse flies which are usually the lower torso and legs.

In another experiment concentration of deltamethrin equal to the previous one (0.0046%) was sprayed on an ox and tsetse allowed to land. A 75% mortality and a 95% knock down effect was observed for upto 8 weeks when the action of deltamethrin lasted (Thompson, 1987). But when pigs and guineapigs were dipped in 0.00375% deltamethrin, and flies allowed to feed, the flies died after a knock down effect. The knock down effect remained high upto day 22 and tsetse mortality was observed upto day 14 (Bossche, 1988; Bossche *et al*, 1988).

Experimental use of cattle as target in the field was first done by Chizyuka and Luguru (1986) in Zambia where cattle were dipped in deltamethrin to control ticks and tsetse. The result showed a decrease in both ticks and tsetse. In another trial in Cameroun, Abiola *et al* (1990) observed that cattle sprayed with deltamethrin attracted five times less tsetse than non treated cattle and the control was effective in reducing the incidence of trypanosomiasis in cattle. In a field trial in Mkwaja ranch Tanzania, Gao *et al* (1990) was able to reduce tsetse population by upto 100% (*G. morsitans*) within 3 months of using cattle dipped in deltamethrin (decatix). In Kenya, flumethrin pour on formulation was used in Witu ranch where *G. pallidipes* were effectively controlled (Lohr *et al* 1990).

1.1.3 Objectives.

In the present study deltamethrin 'pour on' formulation was used in a tsetse infested area (Galana) in Kenya. The main objectives were to study the changes in tsetse population and infection rate during the control. The specific objectives were to:

1. Determine tsetse population changes during control in relation to:

    a - density

    b - age

    c - trypanosome infection rate and species

2. Compare trypanosome infection rates in tsetse with (animal trypanosomiasis) challenge in cattle using berenil indices and PCV readings in sentinel groups kept in the two areas.

1.1.4 Justification

The area chosen for the experimental work is a high challenge one and prone to tsetse re-invasion from the surrounding areas. It was therefore hoped that a comparison of tsetse population changes and berenil indices in the two areas would give information on the nature of the re-invasion of tsetse, if any, into the experimental area. Such information would help evaluate the success of the 'pour on' technique for tsetse control in a Kenyan situation.

The 'pour on' technique should change tsetse population structure such that initially there should be more younger flies. Later on, when the tsetse population has been controlled flies caught should be immigrants which could be of any age but at a much lower density. The trypanosome infection rates and species of trypanosomes in the tsetse would also be affected by the change in population density and fly age structure. This would consequently affect the incidence of trypanosomiasis in cattle.

Based on this assumption, tsetse challenge would be high when tsetse population density is high and composed of relatively old flies but later on it would be expected to decline following the decline of tsetse population density.

1.2 LITERATURE REVIEW

1.2.1 Tsetse Population Composition

The tsetse populations are usually stable when no added control factors are acting on the population such as density dependent or density independent factors. At equilibrium tsetse population has a rate of increase of zero (Rogers and Randolph, 1984). It is clear therefore that even in the absence of external pressure that limits population growth, the population does not increase indefinitely. Hargrove (1988) discussed the factors that limit population growth. He pointed out such factors as pre-adult and adult survival, interlaval period and pupal duration as density dependent factors regulating population growth. Rogers and Randolph (1984) pointed out that only one of the four demographic factors, natality, mortality, emigration and immigration needs to be, but more than one may be density dependent and its action will critically determine the regulation of the tsetse population. Such demographic changes as above can be determined by sampling populations from time to time and determining the age structure. The tsetse population composition in the sample would provide information on mortality rates of the population. However, when the mortality rates are also changing, age categories alone do not give accurate results (Williams *et al*, 1990). The authors simulated a model to estimate mortality rates and set limits on the accuracy of the mortality estimates.

Since tsetse flies breed very slowly, a slight reduction in fecundity or longevity of the females would cause a slow decline of the population to extinction (Vale, 1987). While slight changes in fecundity would have little effect on the population in general, slight changes in death rate would cause obvious changes (Hargrove, 1988). He estimated the maximum death rate of adult females to be 5% per day in a non-decreasing population. In reality the mortality could be about 4% per day.

In tsetse control, the aim is to increase the mortality rate per day slightly beyond that observed due to natural causes (Rogers and Randolph, 1984). Hargrove (1988) estimated that an artificially imposed and sustained female adult mortality of 4% per day would cause a slow decline of the population to extinction even in the most favourable environment.

In most tsetse control programs death rates higher than 4% per day are achieved. For instance in aerial sprays adult death rates of 100% have been achieved in one spray cycle. Thus by the end of the program tsetse reduction may be more than 90%. For instance Davis and Bowles (1978) attained a 99.9% reduction in the Okavango delta area by aerial spraying and re-invasion of the area was slow.

In other aerial spray operations high death rate per day maybe achieved during the insecticide application only to be followed by low reduction of population and consequently a high rate of resurgence. Kuria and Bwogo (1986) obtained a maximum of 72% reduction of tsetse after aerial application of U.L.V. of pyrethroids in Lambwe valley. Earlier attempts to control tsetse in the Lambwe valley by Turner (1984) had achieved a total fly reduction of 99.9%, only to be followed by a high resurgence. In slightly over twelve months, fly numbers in the valley had attained the pre-control levels. Such problems of failure to control tsetse were associated with poor technological application and meteorological problems. However from the point of view of population dynamics, lack of sustained induced mortality was another reason for the failure, though such a programme would prove to be too expensive if sustained for a long period.

Ground spraying with residual insecticides may be successful in imposing a mortality rate enough to cause tsetse decline. The technique however suffers from constraints such as need to respray frequently during the wet season, and environmental destruction with the residual chemicals and therefore limits it's use.

Use of traps and targets maybe successful in reducing population than aerial application. Such a technique being cheap and simple (Vale, 1987) is easily sustained and maintained. The mortality rates imposed by such a technique would be extended for a long period necessary to result in tsetse decline. Vale *et al* (1985) estimated that as low as 1% per day imposed and sustained tsetse mortality rate would be effective to control tsetse. Langley and Weidheas (1986) estimated that trapping only 2% per day of the adults was more effective a control technique than sterilizing males alone or both sexes. And Hargrove (1988) suggested that in most field conditions an added adult mortality rate of only 2.3% would be required to bring the tsetse population to extinction.

In a field trial, Vale *et al* (1986) successfully reduced *G.m. morsitans* and *G. pallidipes* population from lake Kariba island in Zimbabwe by removing only 0.1-0.3% per day of *G. m. morsitans* and 1-4% per day of *G. pallidipes*. In total a reduction of 90% and 99% of *G. morsitans* and *G. pallidipes* respectively were observed. This was followed by targets erected throughout the control area. The adult mortality using the targets was 2% per day of *G. morsitans* and 5% per day of *G. pallidipes*. Total eradication of flies was achieved in 9 months for *G. morsitans* and 11 weeks for *G. pallidipes*. In yet another trial Vale *et al* (1988) reduced fly numbers along Zambezi river by 99.9%. The added mortality rates of the adults was estimated at 2% per day for *G. morsitans* and 10% per day for *G. pallidipes*. In Nguruman, Kenya, Dransfield *et al* (1990) obtained a 90% reduction of *G. pallidipes* using the Ng2B trap. Added daily mortality was 4-5% per day of the adult flies but there was no effect on the small population of *G. longipennis*.

There are no numerical values for estimated mortality rates induced by the 'pour on' tsetse control technique. However, it would be expected that results of such work would closely relate with the observations on targets.

A study on the age categories of fly populations from time to time may provide information on the changes occurring in the population. For instance when proportionately large numbers of young flies relative to older ones are observed then there may be high mortality in a relatively stable population or there may be a low mortality in a growing population (Rogers and Randolph, 1984). Snow (1980) found that flies appear to live longer (i.e higher age categories are obtained) in a population that is increasing than when it is decreasing. Tsetse control therefore will change the population composition depending on the control technique used. In aerial spray for example 100% death rate of the adult flies may be obtained in every spray cycle (Hargrove, 1988). The flies caught thereafter will either be teneral flies emerging in between the spray cycles or old invading flies. In other cases adult females may survive the spraying by developing tolerance to the chemicals (Davies, 1978; Tarimo *et al*, 1984).

When sterilizing techniques are used in tsetse control, juvenile stages are affected. In the absence of reinvasion, the age composition shifts slowly so that there are more old flies than young ones. Hargrove and Langley (1990) found that the average female age category doubled after installation of the autochemosterilizer in Zimbabwe. The factors contributing to such drastic shifts of population composition were high death rates of juveniles and the high immigration rate of the adult flies particularly the female ones. Dransfield *et al* (1990) found that female flies migrate more than males.

When baited traps and targets are used, a slow decline of the adult population is observed. Therefore female age categories will show a relatively younger population in the controlled area. In the event of re-invasion from the surrounding, all age categories may be found. Dransfield *et al* (1990) estimated that young adults (category 1-3) migrate more (48%) than the tenerals (25%) and the older female (category 4-7) (27%). Factors that may alter the age composition from the expected are the sampling techniques. The hand nets for instance catch more younger flies than

old ones (Tarimo *et al*, 1984). Vale and Phelps (1978) discussed the various problems associated with sampling of tsetse flies.

Trypanosome infection rates in the wild tsetse population vary. It is difficult to estimate the average infection rates in any one place. There are also variations depending on the species of tsetse and the pathogenic trypanosome species. Dransfield (1982) found that *G. longipennis* had an infection rate of 1.5% for both *T. congolense* and *T. vivax* while *G. pallidipes* had an infection rate of 3% with *T. vivax* and 1% with *T. congolense*. Paling *et al* (1987) found higher infection rates with *T. vivax* (8.9%) than *T. congolense* (6.9%) in a tsetse survey in Kilifi where *G. austeni* was the main vector. In a tsetse survey in the coast Tarimo *et al* (1984) obtained higher infection rates with *T. congolense* than *T. vivax*.

Moloo and Kutuza (1988) compared the infection rates for Tanzanian and Nigerian stocks of *T. congolense* and Moloo and Kutuza (1988a) compared the susceptibility of different Glossina species to *T.b. brucei* stocks from Tanzania and Nigeria. They found *G.m. centralis* to be a better vector for both species of trypanosome compared with *G. brevipalpis*, *G. palpalis*, *G.p. gambiensis* and *G. tachnoides*. Both the Tanzanian and the Nigerian stocks of *T. congolense* established better (0.3-49.2%) than *T.b. brucei* infection in all the tsetse species and subspecies. Moloo *et al* (1988) compared the performance of sterilized and normal tsetse species as above infected with same trypanosome stocks. He found that the sterility or fertility of tsetse did not affect the trypanosome infections. The trypanosome infection rates were similar to the previous results.

Trypanosome infection rates in tsetse may also be affected by the average temperature. The highest trypanosome infection rates are acquired in tsetse when the average temperatures are highest (Moloo *et al*, 1980). The average adult age of tsetse also influences their infection rates. Older flies were found to have a higher infection rate than younger flies (Rogers and Randolph,

1984). Mohammed *et al* (1989) found that infection rates of adult flies correlated well with the average age of the population.

The food source for tsetse also influences the infection rates and species of trypanosomes. Where tsetse feeds more on bovids there are higher infections with *T. vivax* while if there are more feeds on suids *T. congolense* are higher than *T. vivax* (Jordan, 1976; Tarimo *et al*, 1985).

Rogers and Randolph (1984) observed that to control trypanosomiasis, fly numbers or infection rates should be reduced to below a threshold that is manageable. Once this kind of a regulative measure is achieved flies would be living on average 28 days. This is less than the time required for the *T.b. brucei* to complete its development. The control techniques that therefore interfere with adult longevity would also interfere with transmission of the trypanosomes.

1.2.2 Incidence of Animal trypanosomiasis

A measure of tsetse challenge and trypanosomiasis risk on livestock has on many occasions been used to evaluate the success of a transmission intervention program. Rogers (1985) attempted to define the two terms using past and present knowledge. He defined challenge as the simple product of apparent density and mean fly infection rate, and risk as the mean daily probability of cattle becoming infected. Boyt *et al* (1963) defined risk as the number of treatment per head per annum. Smith and Rennison (1958) had defined trypanosome challenge as the number of infective bites received by a host per year, while Murray *et al* (1983) used the same definition to mean risk. It appears therefore that the terms risk and challenge have been used by various authors interchangeably. Tikubet *et al* (1990) defined it (risk) as the time required for 50% of the host to be infected and Rogers (1985) found that risk and challenge were linearly related.

To estimate these two factors several and varying factors are considered. Leak *et al* (1988) studied three factors; tsetse relative density, trypanosome infection rate and proportion of feeds taken on livestock by tsetse. In order to estimate the challenge they however used the data for only the first two factors. Rawling and Snow (1988) also used the two factors above to estimate trypanosomiasis risk. However Jaquiet (1989) pointed out that human activity also influences the indices of challenge by either promoting the spread of parasite or by reducing the incidence of the disease.

Snow and Tarimo (1983) estimated the trypanosomiasis risk at Diani, Kenya. They used various aspects of tsetse to collect data, such as relative density (mark release recapture), tsetse feeding patterns, trypanosome infection rates and cattle census infections. They concluded that a simple method of estimating challenge would be to use sentinel herd of animals and monitor their infections. Such an estimate can be done using the number of berenil treatments as done by Boyt *et al* (1963) and Rogers (1985).

There is ample evidence now to show that the incidence of trypanosomiasis in cattle correlates well with tsetse population density and their infection rates. Gouteux *et al* (1988) observed that a relative decrease in vector apparent density was related to a lowering of the sero-parasitological prevalence rates. Ikede *et al* (1988) carried out a trypanosomiasis survey in Nigeria and found that in states where vector relative density was low, animal trypanosomiasis was also low. In other states where *G. palpalis* and *G. tachinoides* were common, high prevalence of animal trypanosomiasis was experienced in the tune of 17-28%. Similarly, Jeannin *et al* (1988) observed high incidences of trypanosomiasis in cattle in areas with high to fairly high densities of *G. m. submorsitans* and *G. p. gambiense*. In areas with fairly low fly population either naturally or due to seasonal changes, incidences of trypanosomiasis in cattle were low. In Jos plateau Nigeria, Joshua and Shanthikutmar (1989) detected high infection rates in tsetse and in cattle as well. In another survey in a state ranch in Congo, Goutex *et al* (1990) found an average density of 0.29 flies/trap/day and no detectable parasitaemia was observed in the N'Dama cattle kept in the ranch.

After tsetse control programs animal data are a reliable source of estimate of challenge in order to evaluate the success of the control program. For instance Bauer *et al* (1988) carried out parasitological survey on cattle kept in an area that had been freed of tsetse two years earlier. No parasitemia was detected in the herd while *T. congolense* and *T. brucei* were detected in cattle grazing in the tsetse infested areas. In a tsetse control program using screens and targets, Mawuena (1988) observed a tsetse reduction from 4.6-0.1 flies/trap/day and the incidence of trypanosomiasis in the herd fell from 13.6 to 1.6%. Willemse *et al* (1989) also used a sentinel herd of cattle to assess trypanosome challenge during a tsetse control program using targets. Decrease in parasitological indices of animals was observed following a tsetse control program using traps (Noireau *et al* 1990).

Although control of vector is usually followed by a consequent reduction of infection rates in cattle, some control methods may affect only one species of tsetse occupying an area leaving the

other tsetse species unaffected, thus trypanosome transmission is also unaffected. For instance Ekejindu (1990) used sterile insect technique (SIT) and successfully eliminated the target population of *G. p. palpalis* and left *G. tachinoides* which maintained the transmission of trypanosomes to the sentinel herd in the area.

In Galana ranch berenil index (treatments per animal per annum) dropped from 10 to 1% after tsetse control using targets had successfully reduced the fly numbers. Similar work done at Lambwe valley, Kenya reduced fly numbers from 1500 to 30 flies /trap /day and berenil indices dropped from 6.0% to 0 by the end of the control period (Okech per.comm.).

CHAPTER II

2 TSETSE POPULATION STRUCTURE

2.1. Introduction

Following stressful conditions tsetse population structure is altered. The changes observed mainly depends on the source and magnitude of the stress. For instance insecticidal sprays cause death to most or all of the adults in an area (Davis, 1978). In control programs using targets and traps only a proportion of the flies is effected each day (Dransfield *et al*, 1990). When the sterilizing technique is used lack of emergencies causes reduction in tenerals and young adults (Hangrove and Langley 1990).

Other factors that distort the normal population structure are changes in level of migration probably as a result of changes in population density in one area relative to another area. Old immigrant tsetse caused the average age category to double drastically in a study carried out in Zimbabwe by Hargrove and Langley (1990). Such migrations may occur when control programs succeed in reducing fly numbers in one area leaving certain breeding points unaffected (Wellde *et al*, 1989).

When population structure is affected the types of trypanosome species are also affected. Rogers and Randolph (1984) observed that control may reduce the longevity of flies, such that trypanosomes that take long to develop do not have enough time to complete their development. Transmission of these parasites in cattle will also be effected and therefore change the ratios and the levels of trypanosome incidence in cattle in the area. A study on the tsetse population density will offer information on the effects of the control, while the population structure changes, if any could be evaluated to see if the tsetse population caught in the area is being maintained by immigrating flies.

There are various trap designs that have been used for tsetse control as well as for sampling. For instance the biconical trap (Challier and Laveissier 1973) has been widely employed. Dransfield *et al* (1990) compared the biconical trap with F3 and the Ngu trap. They found that the Ngu trap was comparable with the biconical trap while the F3 was less efficient in catching *G. pallidipes*. The World Health Organisation (WHO) (1988) compared the cost of construction of various traps used for tsetse control. They found the West African vavoa trap cheaper than the biconical trap. However due to the unavailability of the former trap the latter type was used for sampling testse in this work.

3.3 Materials and methods

3.3.1 Study area

Location

The study area was Galana Ranch found in South Eastern Kenya. It extends from Yatta Plateau to the coastal flood plain belt. On the west, the ranch is bounded by Tsavo (East) National Park, to the North by the Orma grazing lands and to the East by Kilifi trust lands inhabited by the Giriama. The Southern boundary is marked by the river Galana Fig. 2. 2.1. The Ranch occupies an area of 600,000 Ha. (Wacher 1986).

Geology.

The landscape is flat with an average elevation of 750 ft above sea level and punctuated by a few widely separated small hills. The hills are outcrops of Duruma Sandstone, a Carboniferous Triassic formation that also forms the underlying basement to the majority of the area. The plains are overlain by soils that are superficially divisible into red and grey soil types.

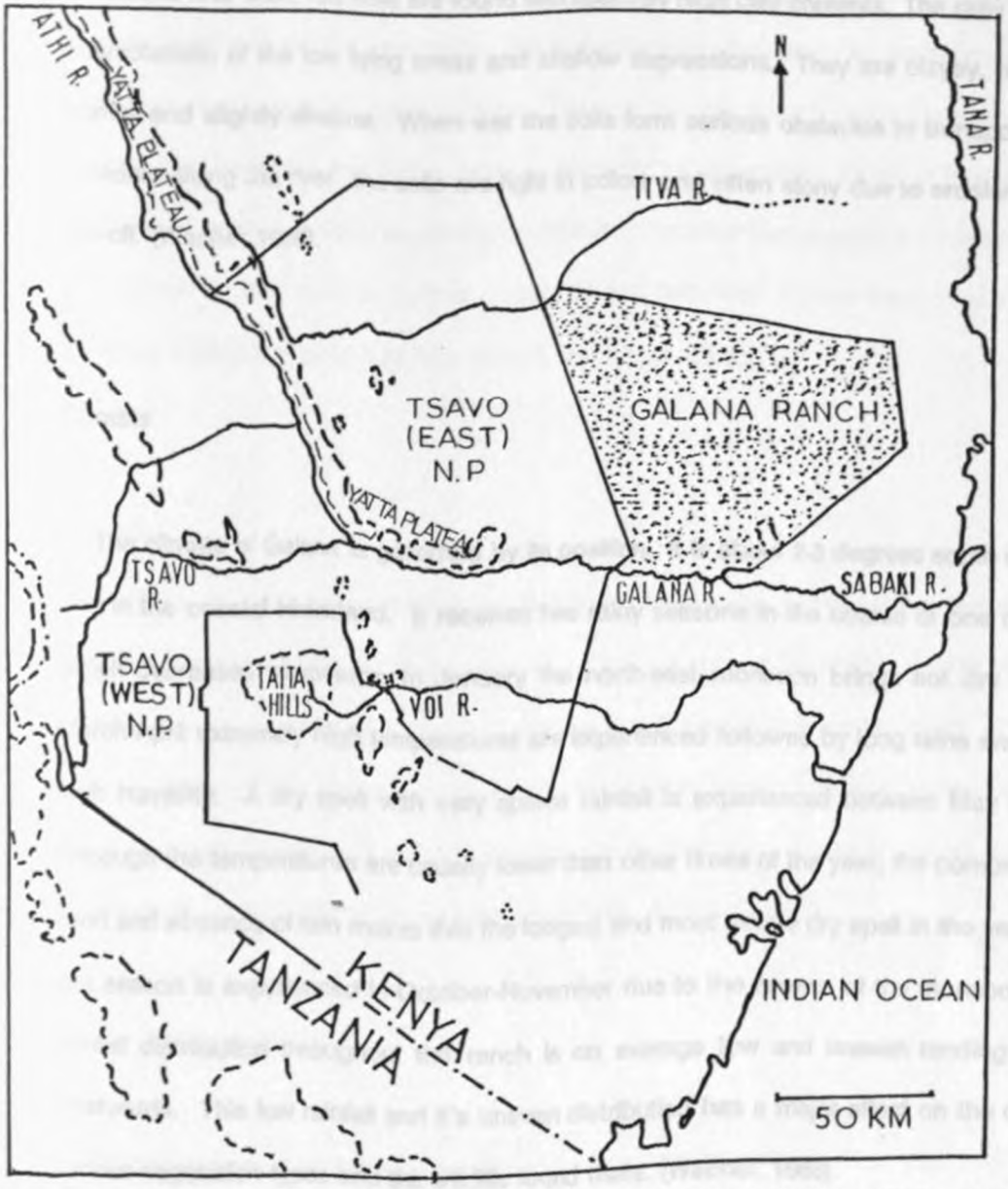

FIG. 2.2.1. LOCATION OF GALANA IN RELATION TO TSAVO (EAST) NATIONAL PARK AND THE COAST.

Red soils are found on top of the shallow catenary sequence. They are acidic, low in organic content with high levels of Fe Ions and low clay contents. In some areas where the catenary gradient is less clear, red soils are found with relatively high clay contents. The grey soils are more characteristic of the low lying areas and shallow depressions. They are clayey, high in organic humus and slightly alkaline. When wet the soils form serious obstacles to transport by wheeled vehicles. Along the river the soils are light in colour and often stony due to erosion from surface run-off. (Wacher 1986).

Climate

The climate of Galana is governed by its position. It is about 2-3 degrees south of the equator and in the coastal hinterland. It receives two rainy seasons in the course of one calendar year, which decreases westwards. In January the north-east monsoon brings hot dry weather. By March-April extremely high temperatures are experienced followed by long rains and consequent high humidity. A dry spell with very sparse rainfall is experienced between May and October. Although the temperatures are usually lower than other times of the year, the combined effects of wind and absence of rain makes this the longest and most severe dry spell in the year. A second wet season is experienced in October-November due to the reverse of the monsoon winds. The rainfall distribution throughout the ranch is on average low and uneven tending to decrease westwards. This low rainfall and it's uneven distribution has a major effect on the distribution of various vegetation types and the wildlife found there. (Wacher, 1986).

Vegetation

The vegetation in Galana is influenced by the east-west climatic gradient and the catenary sequence between red and grey soils. The far eastern side is covered by dense coastal bush, with occasional clearings and large waterholes. Towards the west there is more grass cover than dense vegetation. The central part of the ranch is characterized by uniform stands of bushes and distinct umbrella silhouettes of large succulent Euphorbia. The river bank supports thickets composed of salvadora and trees such as Acacia Domberia and Balanites. Further away from the river dwarf shrubs are abundant near Lali hills. (Heath and Heath, 1988).

Animals

The ranch supports between 22000 and 27000 heads of cattle. These are Boran cattle purchased from the Somalia and the Orma people along the Tana river to the North. Earlier the ranch used to have a lesser number of sheep and camels, but these have been removed. There are also several species of wild animals in the ranch. In addition there are several predators of which the major ones are Cheetahs, lions, leopards and the hunting dog. These predators are responsible for the death of upto 250 heads of cattle each year. (Wacher, 1986).

Tsetse distribution

Thirty five percent of the area is infested by four species of tsetse flies. *Glossina longipennis* occupies the drier parts of the river banks, *G. austeni* used to occupy the river banks but it was almost eradicated from the area during tsetse control using targets (Opiyo *et al*, 1991), *G. brevipalpis* is found in the forested area on the wetter eastern side and *G. pallidipes* is found in the thickets along the river and in the eastern side of the ranch.

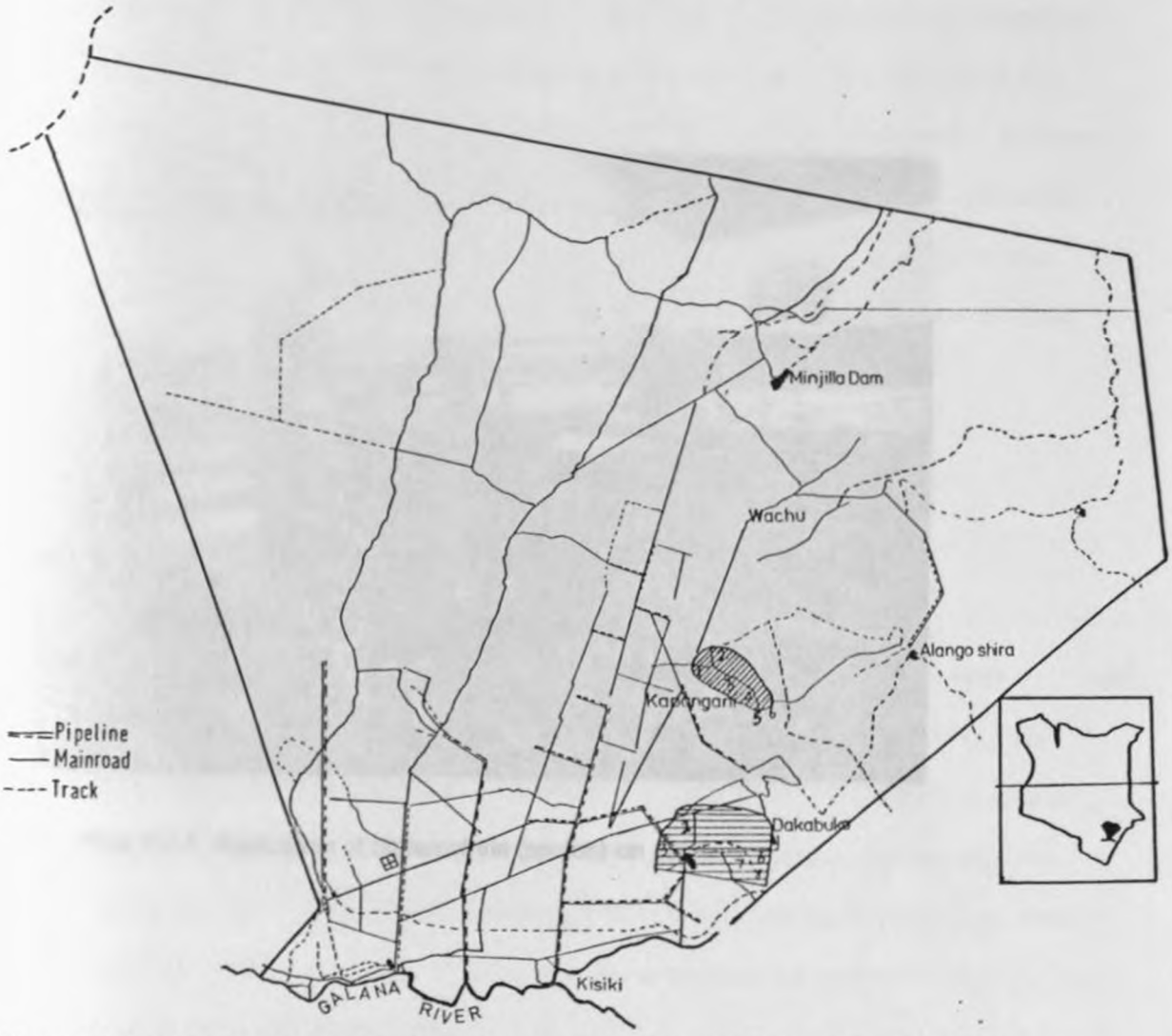

Figure 2.2.2. Galana Ranch showing location of Experimental (▤) and Control (▨) areas

Plate 2.2.1 Application of deltamethrin (spoton) on cattle.

2.2.2 Tsetse Control

Two areas of Galana known to be tsetse infested were chosen. Dakabuku was the experimental area and Kapangani the control one (Fig. 2.2.2). The two areas are ten kilometers away from each other. A herd of 1167 Orma Boran steers was kept in the experimental area, Dakabuku and sprayed with deltamethrin (Spoton diluted at 1% v/w) at a dose rate of 20 ml per animal every two weeks. This was increased to 30 mls per animal when the mean body weight of the cattle exceeded 200kg. An automatic syringe with a special T-shaped applicator was used for applying deltamethrin along both sides of the body (plate 2.2.1). A herd of 100 Orma Boran steers was kept in Kapangani where no tsetse control was done.

2.2.3 Monitoring tsetse suppression.

Monitoring of tsetse was done from December 1989 to September 1991. To assess changes in the population the biconical trap was used (Challier and Laveissiere, 1973) (Plate 2.2.2) baited with phenols in appropriate proportions of 8 parts of p-cressol, 4 parts of octenol and 1 part of propyl phenol in satchets (Owaga, 1988). A 24 hour trapping for two days was done every two weeks. In Dakabuku a set of eight traps was spread out throughout the cattle grazing zone, an area of approximately 50 sq. km. In Kapangani a set of six traps was used in a transect across the cattle grazing area.

Plate 2.2.2 The biconical trap used for monitoring tsetse suppression.

OVARIES LEFT RIGHT	NOTES	ESTIMATED AGE IN DAYS
	Follicle A less than 0·6 mm.	1 — 4
	Follicle A more than 0·6mm.	4 — 10
	Follicle A contracted to be narrow follicular stump Follicle C largest.	10 — 20
	Follicle C contracted to a narrow follicular stump Follicle B largest	20 — 30
	Follicle B contracted to a narrow follicular stump, Follicle D largest	30 — 40
	Follicle A largest, and has follicular stump.	40 — 50
	Follicle C largest, and has follicular stump	50 — 60
	Follicle B largest, and has follicular stump.	60 — 70
	Follicle D largest and has follicular stump	70 — 80

Fig. 2.2.3 To show the changes in the ovaries with increasing age, in Glossina (0 — 80 days); diagramatically.

(Reprinted from Saunders (1960))

2.2.4 Sorting out the flies

The traps were emptied after 24 hours and the flies sorted out in terms of species, sex, teneral and non-teneral status (teneral flies being recognized by their relatively soft thorax). The flies in the various categories were counted and recorded. Total fly catch for the two days was used to calculate the mean fly number per trap per day.

2.2.5 Age grading

Age grading of the flies was done from January to September 1991. A proportion of the non-teneral female flies was dissected each day for age grading. The flies were aged using the method of Saunders (1960) and Challier (1965). Note was made of the presence or absence of follicular relics, the size of the follicles and the position of the largest ovariole and the uterus contents (Fig. 2.2.3).

2.2.6 Infection rates

Monitoring of infection rates in flies was done from January to September 1991. A proportion of the non-teneral flies (males and females) were dissected from both areas and examined for trypanosomes. The identification of the parasite was done by their location in the tsetse as described by Lloyd and Johnson (1924). Infections in the proboscis alone were assigned to Duttonella group, infections in the proboscis and gut were assigned to Nannomonas group and infections in the proboscis, gut and salivary gland assigned to Trypanozoon group.

In all the experiments Analysis of Variance (ANOVA) was applied to test the significance of variations of trypanosome infection rates in tsetse and tsetse ages. The significance level was considered at 0.05 in all the tests.

Athough the experiments started in December 1989, age structure and infection rates in flies was assessed from January to December 1991. Thus the results discussed are for data collected in that period unless where otherwise stated.

2.3 Results

2.3.1 Climate

During the period of study (January to September 1991), only one rainfall season was covered. This was the mid year rainy season (long rains) which had a peak in April (Fig. 2.3.1). Some rain was recorded in January, however, which was followed by a dry period in February. The long rains started in March and increased to maximum in April and declining thereafter upto the end of the study period.

The relative humidity (Fig. 2.3.1) and Temperatures had similar variability (Fig. 2.3.2). The relative humidity was lowest during the driest month of February and highest immediately after the heavy downpour in May. There was a gradual decline of relative humidity until September when a relative humidity of 45% was recorded. The maximum temperatures were highest from January to March and lowest in May. No readings for maximum temperatures were taken between June and August due to technical problems. The maximum temperatures were highest in January and decreased gradually to 19°C in September.

2.3.2 Monitoring tsetse population

Data provided in Figure 2.3.3 and 2.3.4 show fly trap catches per day from December 1989 to September 1991. When the experiment was started, tsetse population was monitored weekly from week 0 to week three. Thereafter it was carried out every two weeks.

Figure 2.3.3 shows trap catches for *G. longipennis* in Dakabuku and Kapangani. Prior to the control *G. longipennis* population was quite high, (15 flies per trap per day). This population

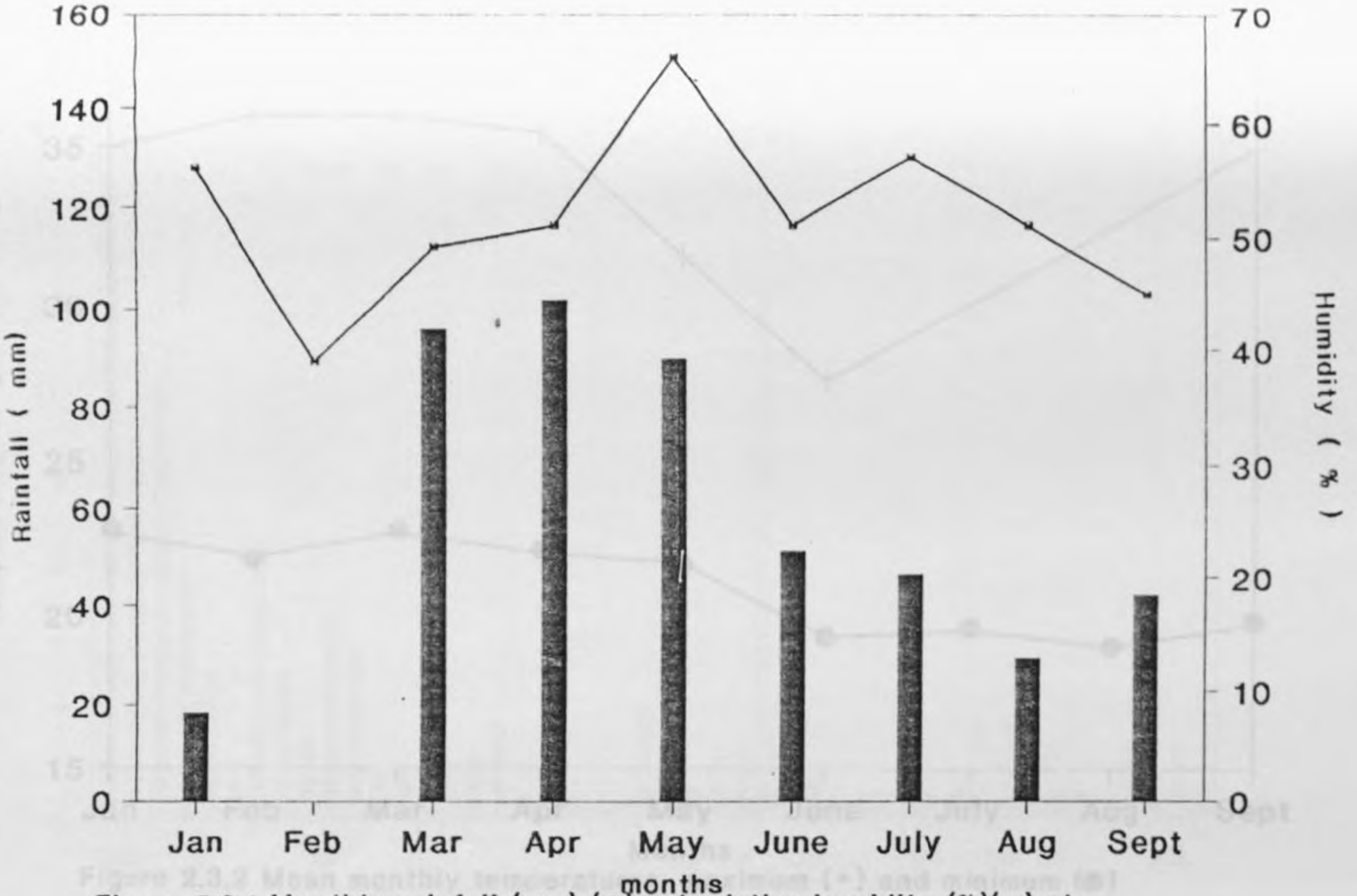

Figure 2.3.1 Monthly rainfall (mm) (■)and relative humidity (%)(⊟) at Tank E in Galana from January to September 1991.

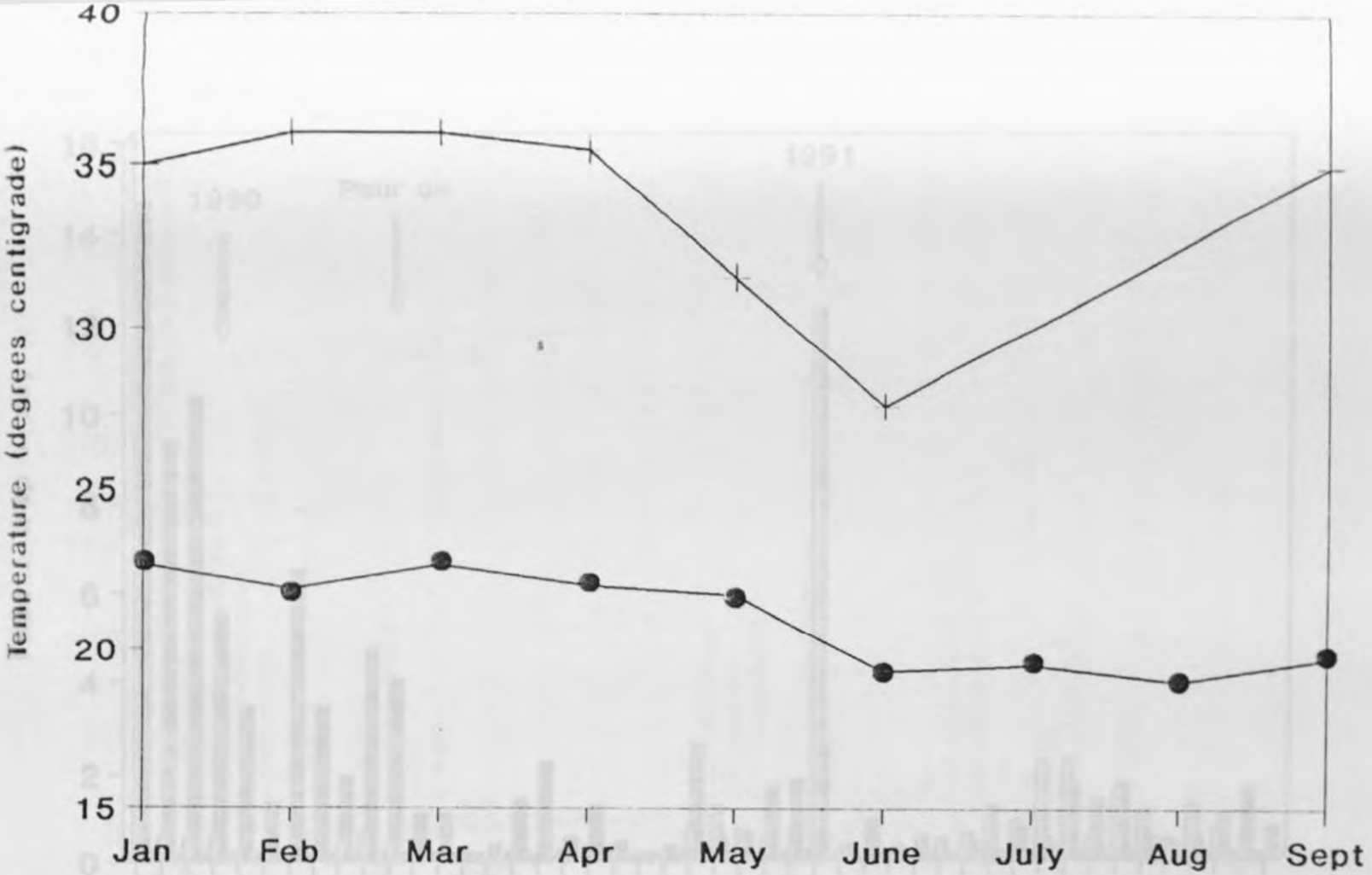

Figure 2.3.2 Mean monthly temperatures, maximum (+) and minimum (●) at Tank E (Galana) from January to September 1991.

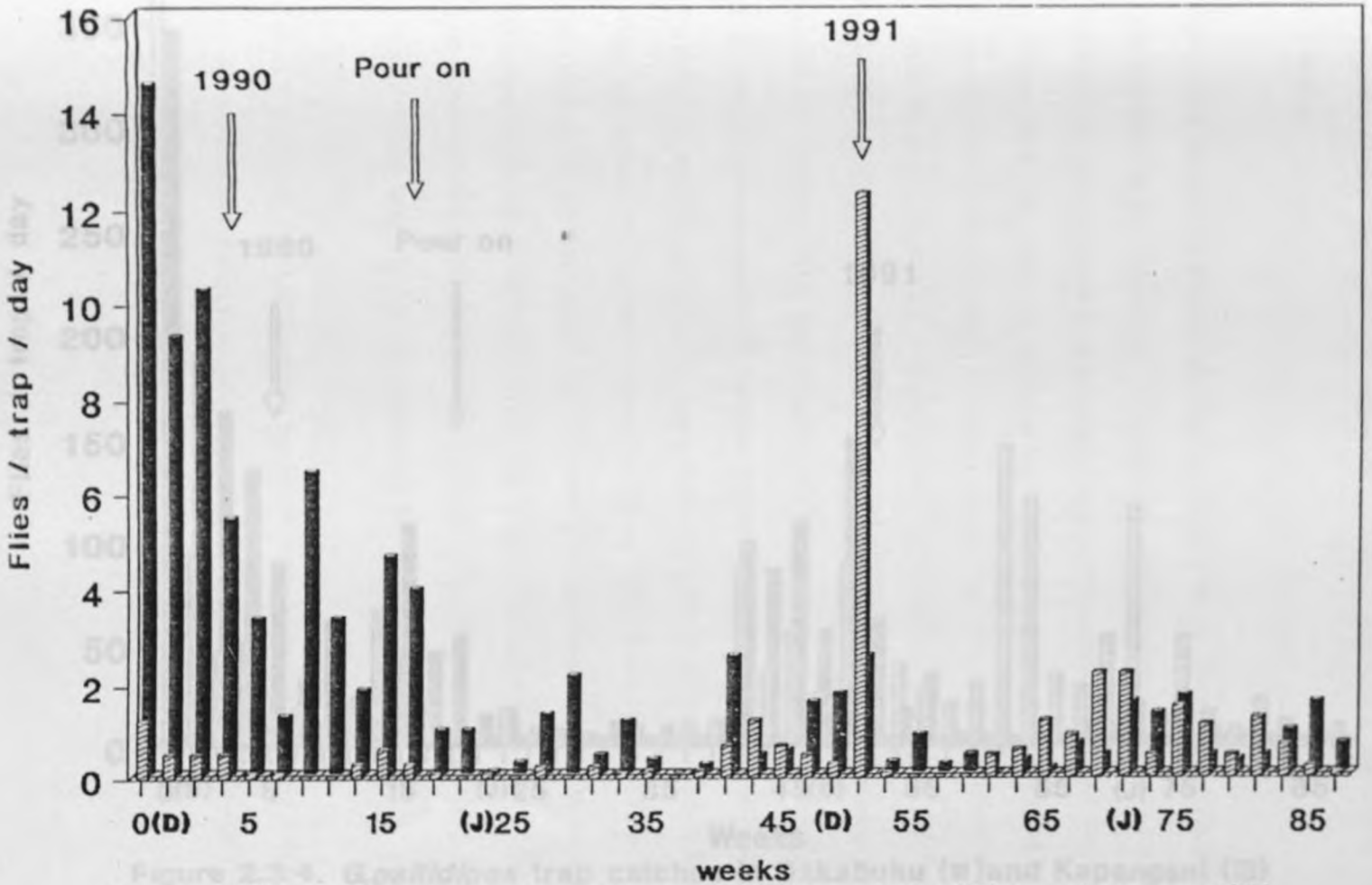

Figure 2.3.3. *G.longipennis* trap catches in Dakabuku (■)and Kapangani(▨) from December 1989 to September 1991.(months).

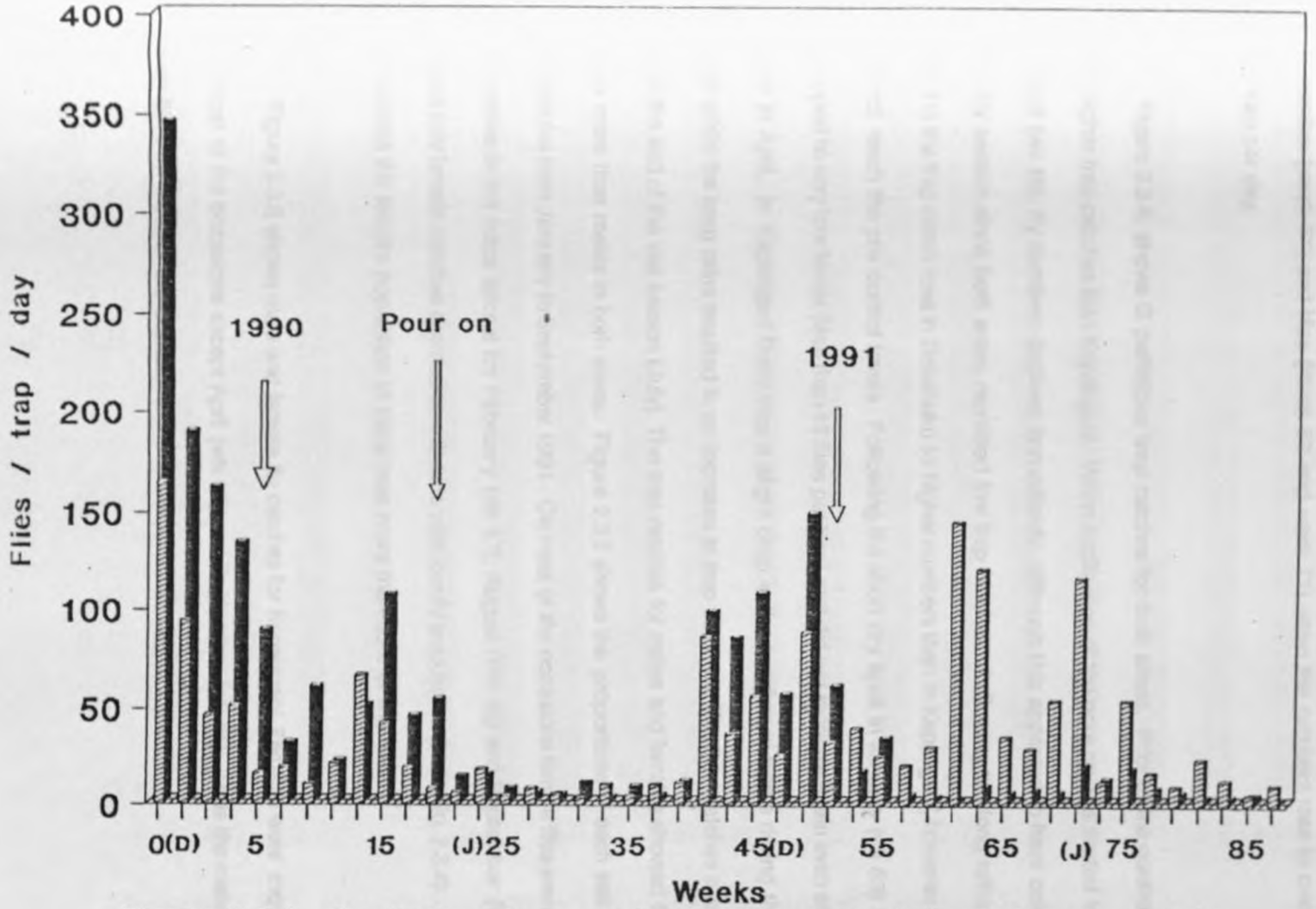

Figure 2.3.4. *G.pallidipes* trap catches in Dakabuku (■)and Kapangani (▨) from December 1989 to September 1991.(months).

declined drastically in April (week18) when insecticide (deltamethrin) application began. From then on fly numbers per trap oscillated between zero to three flies per trap but did not attain the original number. In Kapangani the number of flies per trap were relatively low except for occasions such as December (week 51) and May (Week 69 and week 71) when the numbers rose to over three flies per trap per day.

Figure 2.3.4. shows *G. pallidipes* trap catches for both areas. Prior to the control Dakabuku had higher trap catches than Kapangani. When application of the pour on was started in Dakabuku in April (wk 18), fly numbers declined immediately, although this appeared to have coincided with the dry season since both areas recorded low trap catches. Following the long rains in October (wk 41) the trap catch rose in Dakabuku to higher numbers than in Kapangani, however the number did not reach the pre control levels. Following the short dry spell in January (wk 53) the number dropped to very low levels (less than 15 flies per trap) and did not increase again even after the long rains in April. In Kapangani there was a slight drop in the number of tsetse during the short dry spell while the long rains resulted in an increase in trap catches. The trap catches again dropped after the end of the wet season (July). The trap catches for males and females showed that females were more than males in both areas. Figure 2.3.5 shows the proportions of each sex of tsetse in Dakabuku from January to September 1991 . On most of the occasions female flies were more than the males in the traps except for February (wk 57), August (Wk 82) and September (Wks 85-87). These low female catches seemed to coincide with low fly population (as in Fig. 2.3.4). On all other occasions the female population in traps was more than 50% of the total.

Figure 2.3.6 shows male and female fly catches for Kapangani. Females were more than 50% on most of the occasions except April (wk 67) and September (wk 85) . Thus the males were less than 50% on most of the occasions.

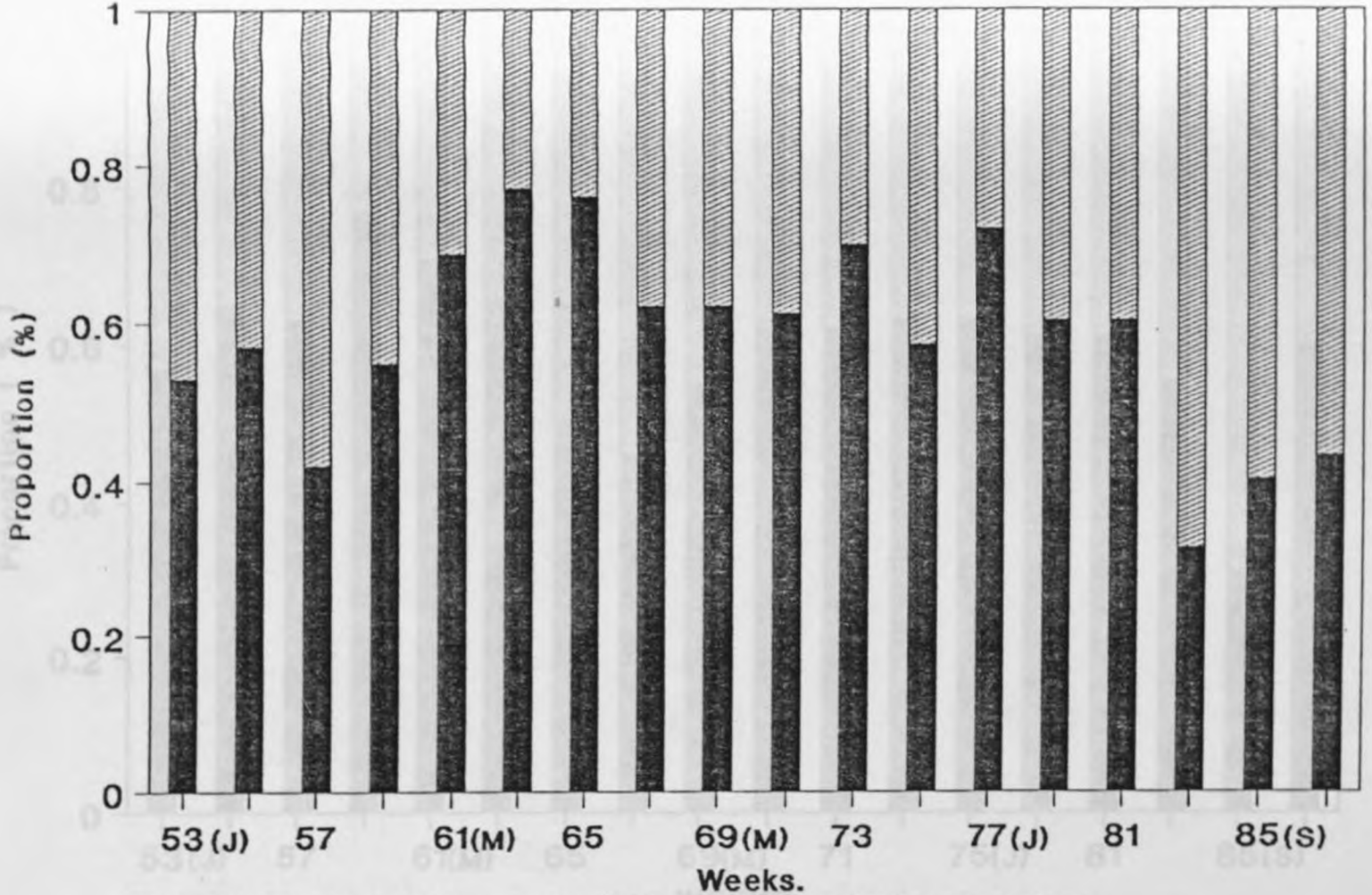

Figure 2.3.5. *G.pallidipes* male (▨) and female (■) proportions in Dakabuku from January to September 1991.(Months).

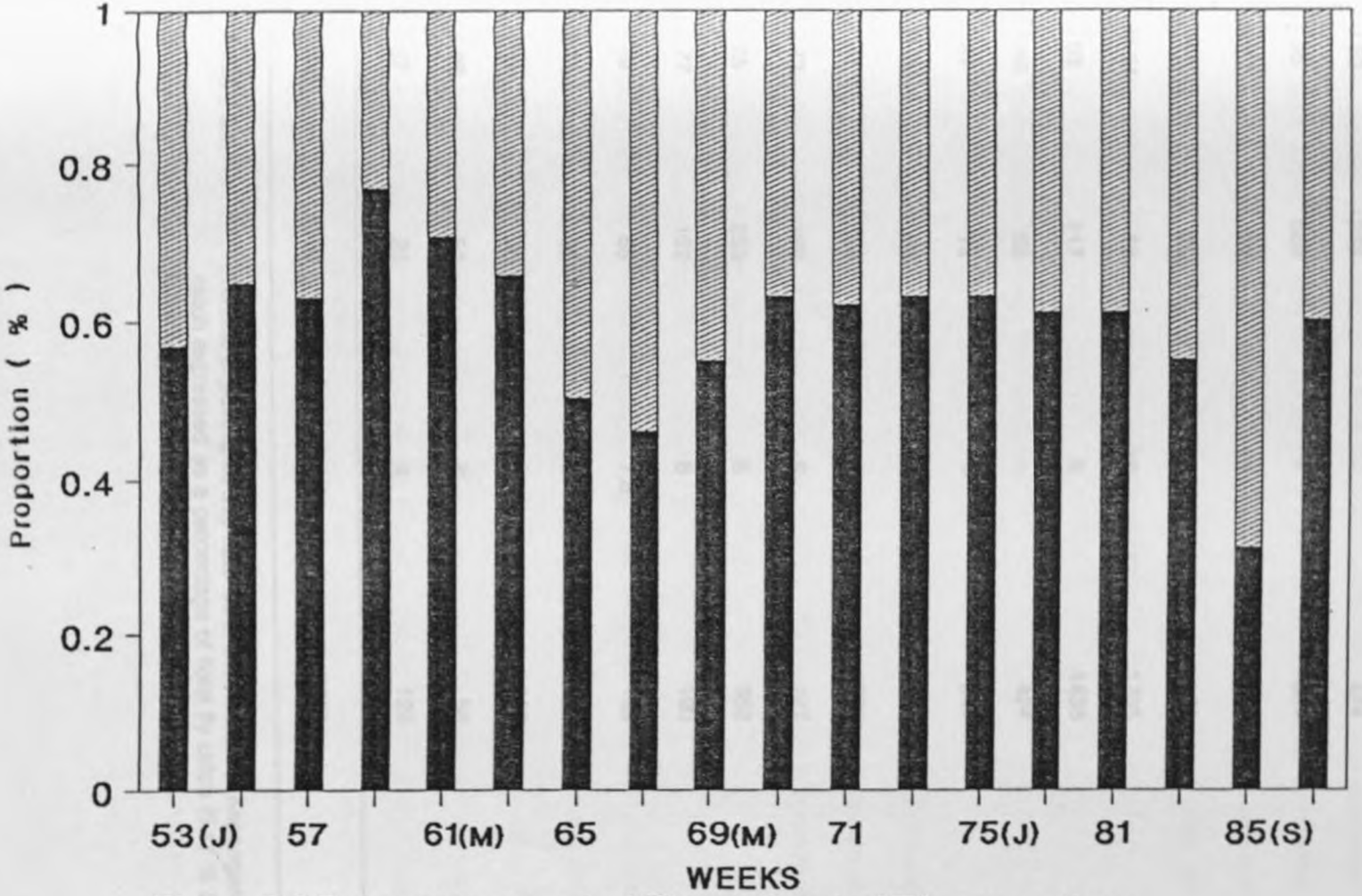

Figure 2.3.6 *G.pallidipes* male (▨) and female (■) proportions in Kapangani from January to September 1991. (Months).

	Dakabuku		Kapangani	
Weeks	Total Catch	Teneral Proportion (%)	Total Catch	Teneral Proportion (%)
J 53	243	-	474	-
55	529	-	304	-
F 57	52	13	235	13
59	29	24	356	3
M 61	13	38	1735	8
63	117	9	1436	9
A 65	63	-	424	-
67	74	-	347	-
M 69	63	6	647	4
71	294	8	1396	11
J 73	168	6	127	22
75	255	5	652	3
J 77	102	8	190	3
79	65	7.6	109	4
A 81	25	36	276	10
83	26	9	139	9
S 85	52	6	58	22
87	23	4	120	3
Total	2193	5.17	9025	6.58

Table 2.3.1. Teneral *G. pallidipes* trap catches in Dakabuku and Kapangani. Total teneral catch expressed as a percentage of total fly catch (5.17 % Dakabuku and 6.58 % Kapangani)

Monitoring of teneral flies began in February (wk 57). Table 2.3.1. shows proportions of teneral flies as percentage of total population. In Dakabuku teneral fly proportions were relatively low compared to non teneral flies. Except for February (wks 57 and 59), March (wk 61) and August (wk 87), the proportion of teneral flies was less than ten percent of total fly catch on all other occasions. In both areas teneral flies were not sorted out in April (wk 65 and 67) due to technical problems. Similarly in Kapangani the teneral proportion was relatively low. Values more than ten percent of total fly catch were recorded only on weeks 57,71,73,81 and 85. There were no significant differences between the teneral proportion in the two areas.

2.3.3 Tsetse Population age Distribution

Studies on age distribution of flies started in January 1991, eight months after the deltamethrin trial had began. To estimate the age structure, only females were used. An estimate of the age by wing fray (applicable for males) could not be used because flies remained in the collector for more than 24 hours before being emptied.

Figure 2.3.7 shows female *G.pallidipes* age distribution in Dakabuku. Generally it would appear that there were more younger flies in January and February than in other months. There were higher proportions of younger age categories (0,1,2) during these two months. From March to July all age categories had proportions less than 20 percent. This means that no age category had an exaggerated higher proportion than the others. In August and September, however, older categories had higher proportions.

In Kapangani, (Fig. 2.3.8) higher proportions of older age categories (4,5,6,7) were observed from January to March. Thereafter younger age categories (0,1,2 and 3) predominated in the population.

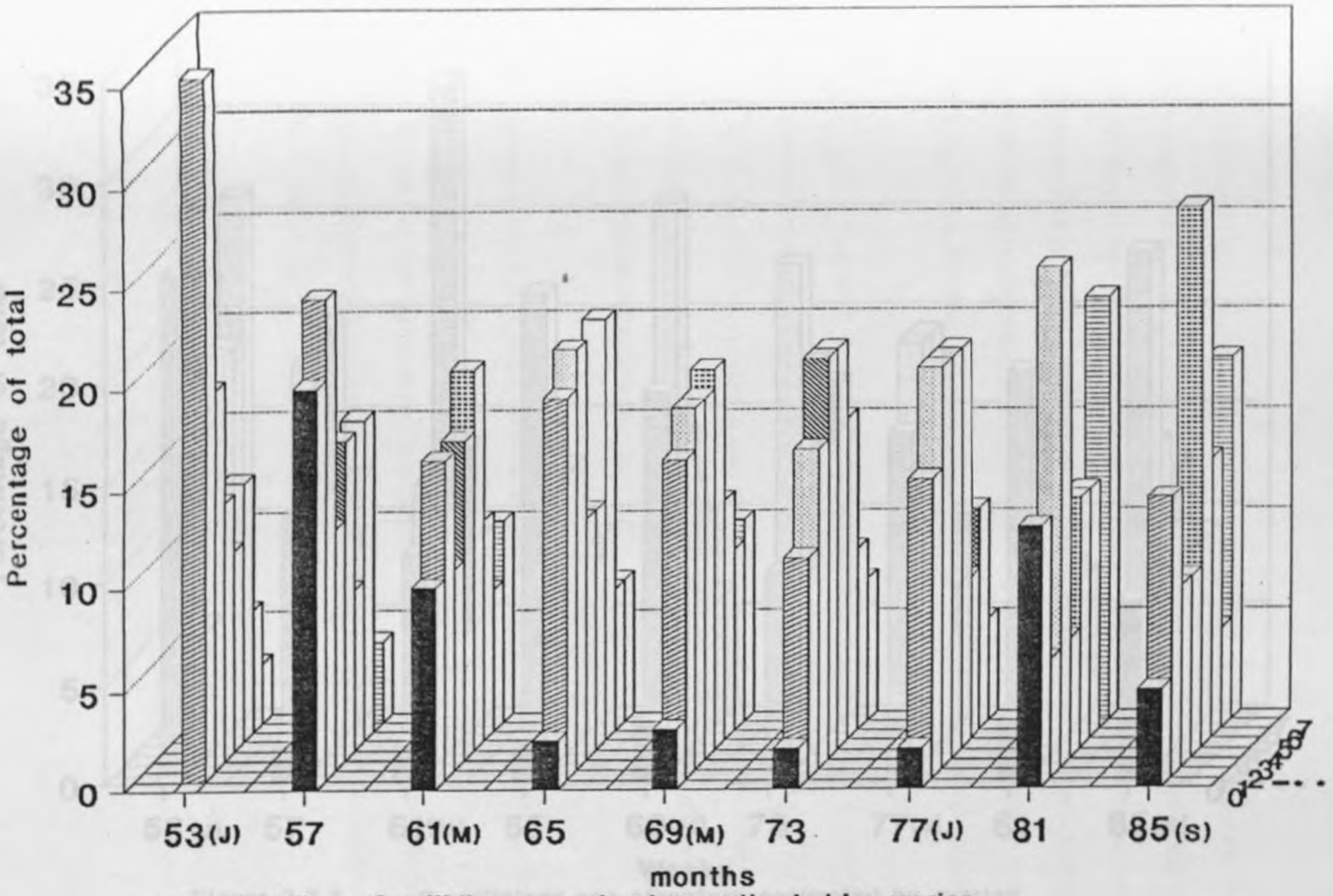

Figure 2.3.7 *G.pallidipes* age structure estimated by ovarian dissection in Dakabuku from January to September 1991.
• • - Age categories 0 - 7. (months).

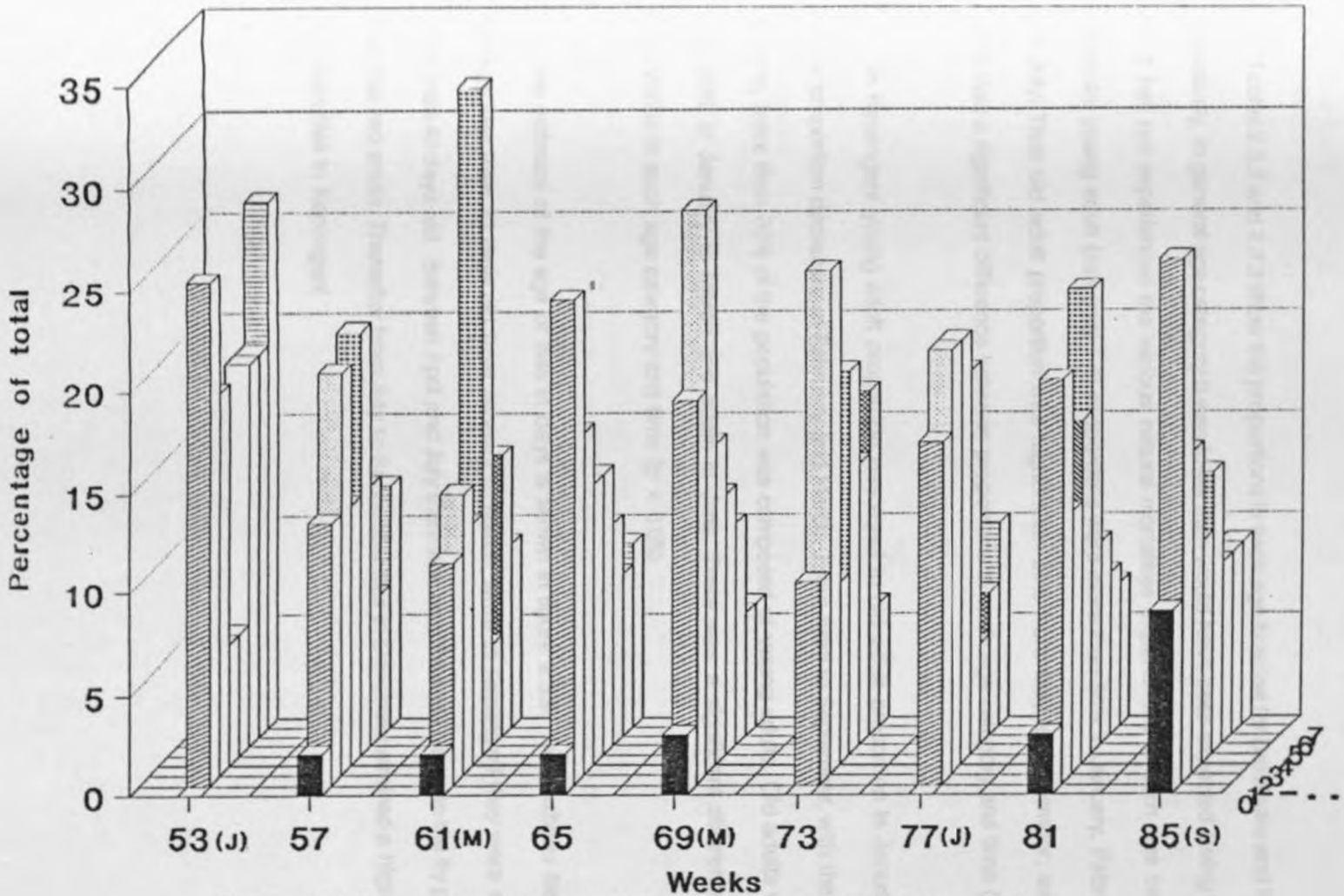

Figure 2.3.8 *G.pallidipes* age structure estimated by ovarian dissection in Kapangani from January to September 1991.
• • - Age categories 0 -7.(months).

The flies were further classified into young ones (Age category 0), young adults (age category 1-3) and old adults (age category 4-7). This further classification was necessary because flies behave differently in each age bracket; besides, age category 4-7 may include much older flies, thus denoted as 4+ to 7+.

Tables 2.3.2 and 2.3.3 show the proportions in each age bracket for Dakabuku and Kapangani respectively. In general age category 0 was lower than would have been expected owing to the fact that it has not experienced the various natural mortalities experienced in each age category. In Dakabuku young adult (category 1-3) proportions were more than 50% in January, February, April and July. Thus old adult proportion was higher than 50% from May to September, except July. There was a significant difference between proportions in each age category and time ($p < 0.05$).

In Kapangani young adult proportion was equal to old adult proportion in January but the former proportion decreased in February and March. From April to September, with the exception of June, more than 50% of the population was composed of young adults. Old adults were more than 50% in January to March and again in June. There was a significant difference between proportions in each age category and time ($p < 0.05$).

An estimate of the age of flies in days is shown in figure 2.3.9. In Dakabuku flies were on average less than 32 days old from January to March, while in Kapangani they were on average more than 40 days old. Between April and July there was no difference between the fly populations from the two areas. Thereafter from July to September flies in Dakabuku attained a higher average age than flies in Kapangani.

Age category Months	0	1-3	4+-7+
January	0	67	33
February	20	52	28
March	10	42	47
April	2	52	47
May	3	38	50
June	2	47	52
July	2	55	44
August	13	37	50
September	5	32	64
Mean	6	48	46

Table 2.3.2 Prorpotions (%) of *G.pallidipes* in age brackets 0, 1-3 and 4+-7+ in Dakabuku from January to September 1991

Age category Months	0	1-3	4+-7+
January	0	50	50
February	2	46	53
March	2	37	61
April	2	55	42
May	3	62	35
June	0	44	56
July	0	59	41
August	3	50	48
September	9	51	41
Mean	2	50	48

Table 2.3.3 Prorpotions (%) of *G. pallidipes* in age brackets 0, 1-3 and 4+-7+ in Kapangani from January to September 1991

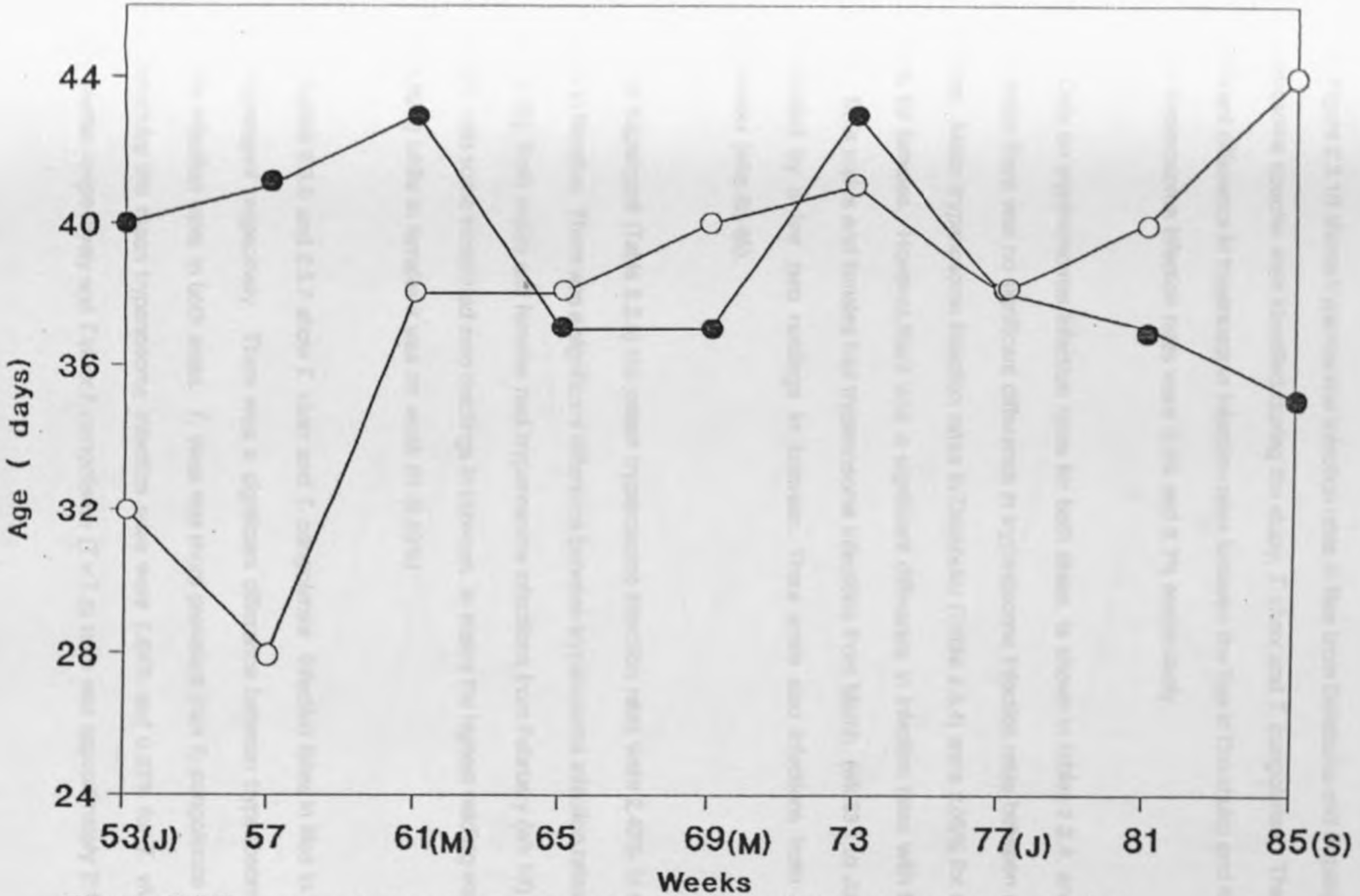

Figure 2.3.9 Average age in days of female *G.pallidipes* in *D*akabuku (○) and Kapangani (●)from January to September 1991.(month).

2.3.4 Trypanosome infection rates in flies

Figure 2.3.10 shows trypanosome infection rates in flies from Dakabuku and Kapangani. Two trypanosome species were identified during the study, *T. vivax* and *T. congolense*. There was no significant difference in trypanosome infection rates between the flies in Dakabuku and Kapangani. Mean trypanosome infection rates were 2.5% and 2.7% respectively.

Data on trypanosomes infection rates for both sexes, is shown in tables 2.3.4. and 2.3.5. In both areas there was no significant difference in trypanosome infection rates between males and females. Mean trypanosome infection rates in Dakabuku (Table 2.3.4) were 2.05% for males and 2.86% for females. However, there was a significant difference in infection rates with time, ($p < 0.05$). Both males and females had trypanosome infections from March (wk 63) to July (wk 77) punctuated by a few zero readings in between. There were also infections from August to September (wks 83-85).

In Kapangani (Table 2.3.5) the mean trypanosome infection rates were 2.49% in males and 2.89% in females. There was a significant difference between trypanosome infection rates with time, ($p < 0.05$). Both males and females had trypanosome infections from February (wk 57) to August (wk 87) with some intermitted zero readings in between. In males the highest reading was on week 81 (9.89%) while in females it was on week 61 (8.89%)

Tables 2.3.6 and 2.3.7 show *T. vivax* and *T. congolense* infection rates in flies in Dakabuku and Kapangani respectively. There was a significant difference between trypanosome species specific infection rates in both areas. *T. vivax* was more prevalent than *T. congolense* ($p < 0.05$). In Dakabuku the mean trypanosome infection rates were 1.64% and 0.87% for *T. vivax* and *T. congolense* respectively and *T.vivax*:*T.congolense* (T.v:T.c) ratio was approximately 2:1. In

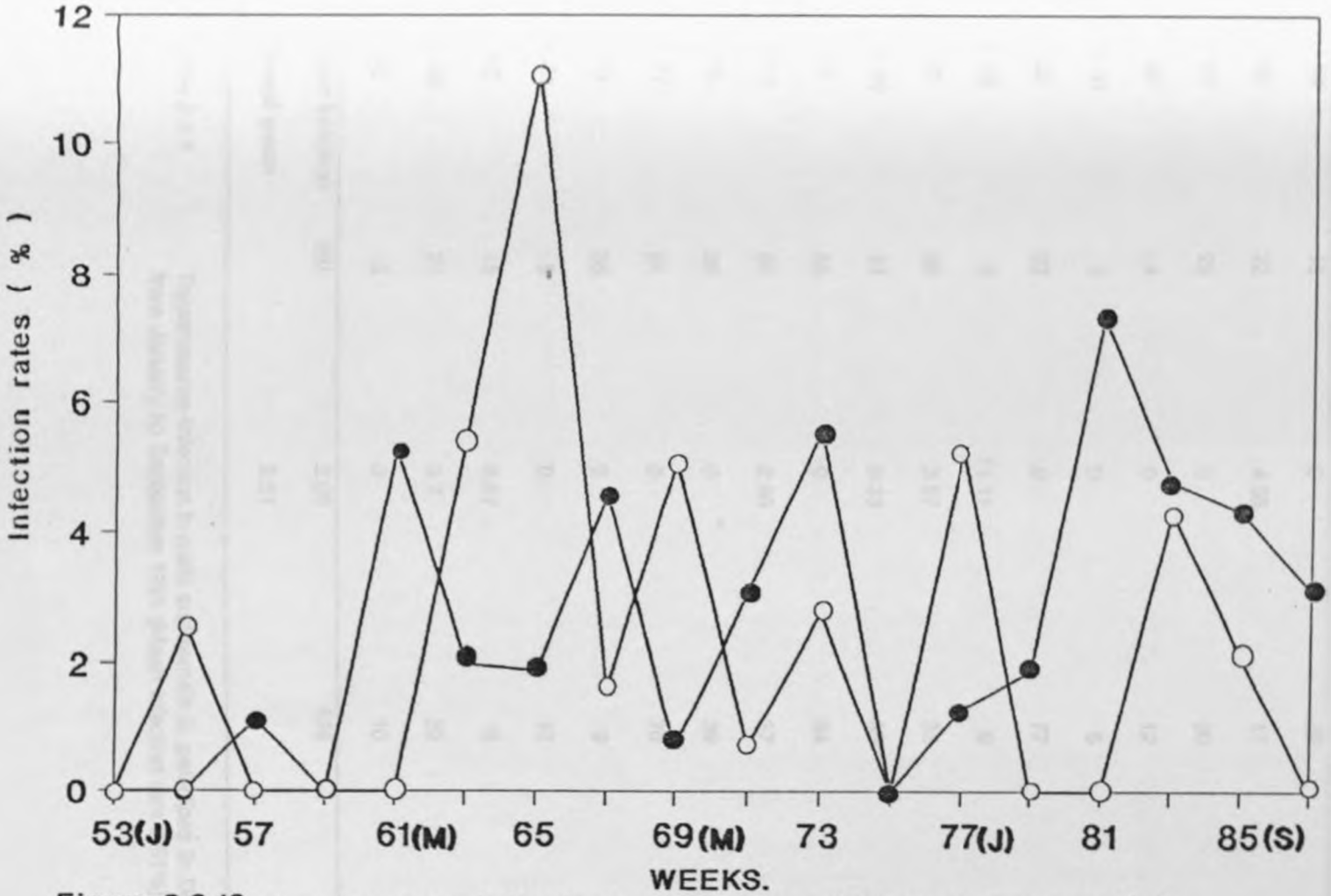

Figure 2.3.10 Trypanosome infection rates in *G. pallidipes* in Dakabuku(○) and Kapangani(●)from January to September 1991.(months).

	Males		Females	
Weeks	Number dissected	Infection rate(%)	Number dissected	Infection rate(%)
J 53	13	0	29	0
55	22	4.55	17	0
F 57	22	0	20	0
59	4	0	12	0
M 61	2	0	5	0
63	32	0	77	7.79
A 65	9	11.11	9	11.11
67	28	3.57	33	0
M 69	24	8.33	35	2.86
71	58	0	84	1.19
J 73	35	2.86	37	2.7
75	26	0	39	0
J 77	24	0	70	7.14
79	36	0	9	0
A 81	5	0	10	0
83	15	6.67	8	0
S 85	27	3.7	20	0
87	9	0	10	0
Mean infection	391	2.05	524	2.86
Overall mean		2.51		

Table 2.3.4. Trypanosome infection in male and female *G. pallidipes* in Dakabuku from January to September 1991 (Mean infection rate 2.51%)

	Males		Females	
Weeks	Number dissected	Infection rate(%)	Number dissected	Infection rate(%)
J 53	7	0	34	0
55	16	0	26	0
F 57	46	0	47	2.13
59	50	0	85	0
M 61	86	3.49	45	8.89
63	102	0.98	100	3
A 65	68	2.94	90	1.11
67	65	3.08	43	6.98
M 69	175	0	97	2.06
71	63	4.76	133	2.26
J 73	27	3.7	45	6.67
75	65	0	37	0
J 77	67	1.47	92	1.09
79	32	3.13	21	0
A 81	91	9.89	100	5
83	53	5.66	72	4.17
S 85	26	3.85	21	4.76
87	46	0	52	5.77
Mean infection	1085	2.49	1140	2.89
Overall mean		2.69		

Table 2.3.5. Trypanosome infection rates in male and female *G. pallidipes* in Kapangani from January to September 1991 (Mean infection rate 2.69 %)

		T.vivax	*T. congolense*
Weeks	Number dissected	Infection rate(%)	Infection rate(%)
J 53	42	0	0
55	39	2.56	0
F 57	42	0	0
59	16	0	0
M 61	7	0	0
63	109	4.59	0.92
A 65	18	5.56	5.52
67	61	1.61	0
M 69	59	1.69	3.39
71	142	0.7	0
J 73	72	0	2.76
75	65	0	0
J 77	94	3.19	2.13
79	45	0	0
A 81	15	0	0
83	23	4.35	0
S 85	47	2.13	0
87	19	0	0
Mean infection	915	1.64	0.87
Overall mean		2.51	

Table 2.3.6 Trypanosome species (*Trypanosoma vivax* and *T. congolense*) specific infection rates in *G.pallidipes* in Dakabuku from January to September 1991 (Mean infection rate 2.51 %)

Weeks	Number dissected	*T.vivax* Infection rate(%)	*T.congolense* Infection rate(%)
J 53	41	0	0
55	42	0	0
F 57	93	0	1.08
59	135	0	0
M 61	131	5.34	0
63	202	0.99	0.99
A 65	158	0.63	1.27
67	108	2.76	1.85
M 69	272	0.74	0
71	196	2.55	0.51
J 73	72	2.78	2.78
75102	0	0	
J 77	159	1.26	0
79	53	1.89	0
A 81	191	5.76	1.57
83	125	4	0.8
S 85	47	2.13	2.13
87	98	3.06	0
Mean infection	2225	2.02	0.67
Overall mean		2.69	

Table 2.3.7 Trypanosome species (*T.vivax* and *T.congolense*) specific infection rates in G. pallidipes in Kapangani from January to September 1991 (Mean trypanosome infetion rate 2.69%)

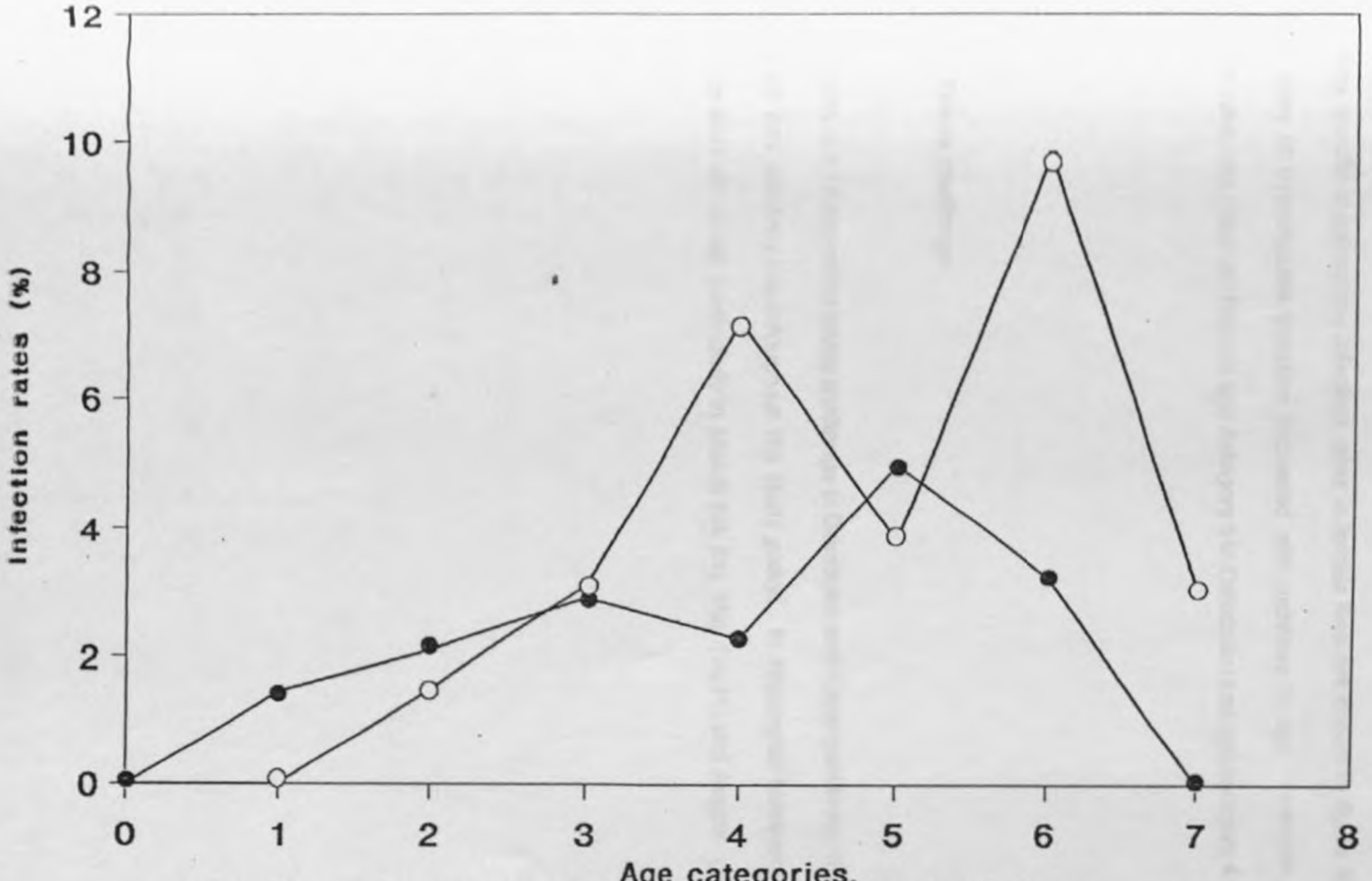

Figure 2.3.11 Age specific trypanosome infection rates in female *G. pallidipes* in Dakabuku (○) and Kapangani (●) from January to September 1991.

Kapangani the mean trypanosome infection rates were 2.02% and 0.67% for *T.vivax* and *T.congolense* respectively and the T.v:T.c ratio was approximately 3:1.

Age specific trypanosome infection rates in female flies are shown in figure 2.3.11. In both areas, rates of trypanosome infection increased with increase in age. However, a decline in infection rates was observed beyond age category 5 in Dakabuku and age category 4 in Kapangani.

2.3.5 Tsetse challenge

Figure 2.3.12 shows the tsetse challenge in Dakabuku and Kapangani areas. In Dakabuku the challenge was relatively low throughout the study period. In Kapangani however, high levels of challenge were observed particularly in March (wk 61), May (wk71) and August (wk81).

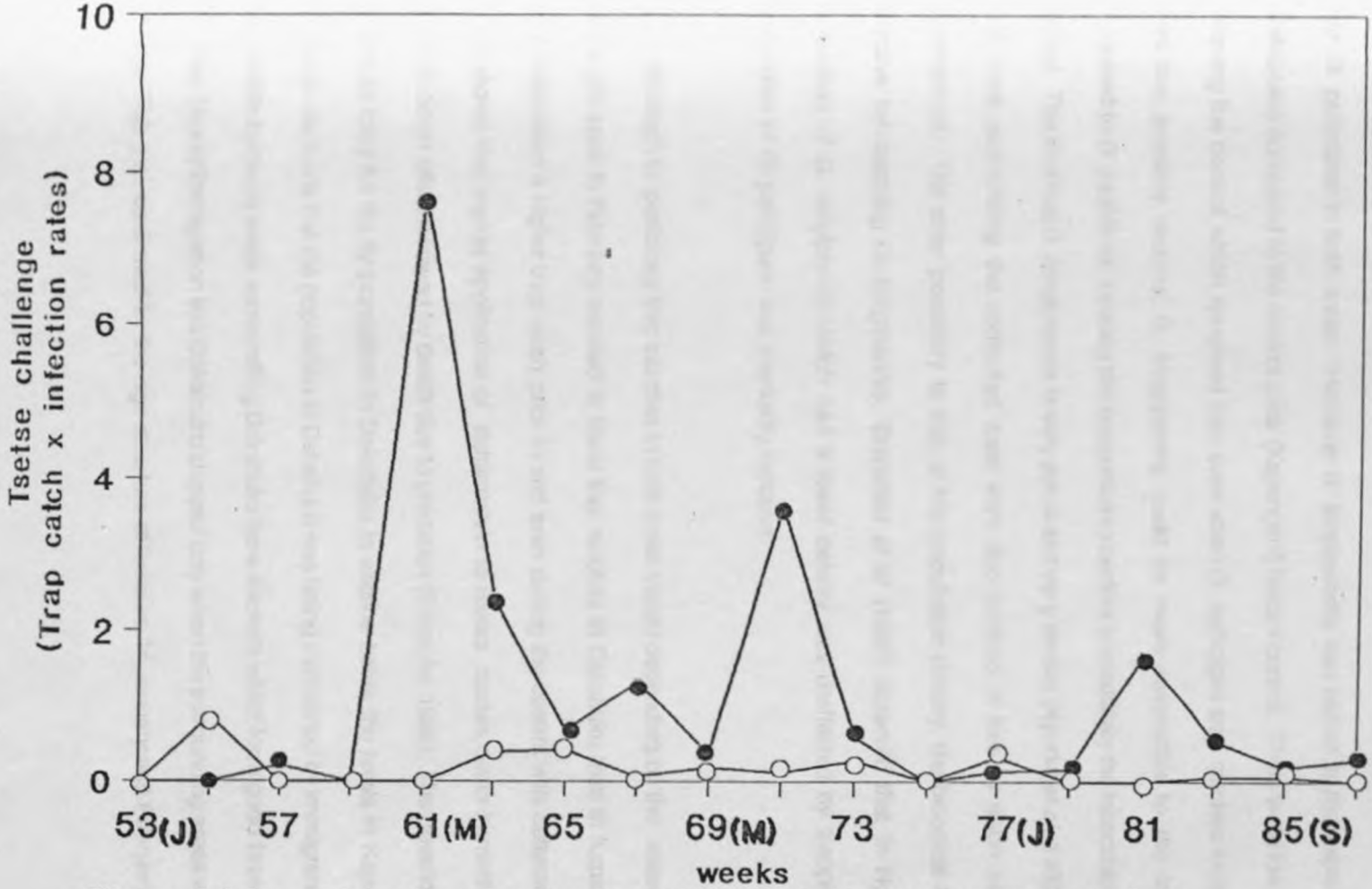

Figure 2.3.12 Mean fortnightly *G.pallidipes* challenge in Dakabuku(○) and Kapangani (●) from January to September 1991. (Months).

2.4 DISCUSSION

Although previously four tsetse species have been reported in Galana (Njogu *et al*, 1986), only two species were encountered during the period of this study. *G. longipennis* was in lower density than *G. pallidipes* in both areas. However *G. longipennis* was higher in the experimental area (Dakabuku) compared to the control area (Kapangani) before control. There were low trap catches following the control, which remained thus even when *G. pallidipes* trap catches increased. There were two possible reasons; *G. longipennis* could be more susceptible to the insecticide as compared to *G. pallidipes*, causing the population to decline immediately the insecticide application started. The fact that *G. longipennis* is very active and very mobile (Kyorku *et al*, 1990), may mean that areas surrounding the controlled zone were also cleared of flies as soon as the control commenced. The other possibility is that, at low population density, the biconical trap was not effective for catching *G. longipennis*. Dransfield *et al* (1990) observed that in Nguruman the population of *G. longipennis* which had a lower density was unaffected by trapping while *the population of G. pallidipes* was markedly reduced.

Although *G. pallidipes* trap catches in both areas varied depending on the season, the onset of the dry spell in February resulted in lower trap catches in Dakabuku than in Kapangani, which had maintained a higher trap catch prior to and even during the control with deltamethrin. It has been shown that topical application of deltamethrin to tsetse causes death immediately or after a knock down effect followed by death due to predation (Bossche, 1988). The question is, why did it take so long for the fly population in Dakabuku to decline below the levels in Kapangani? The probable reason is that the population in Dakabuku was being maintained by immigrant tsetse. This is possible because areas surrounding Dakabuku have thickets which form good breeding sites for the flies. Heavy immigration into Dakabuku stopped only when the surrounding areas were deprived of flies. This was confirmed by the age structure of females. In January and February flies caught

in Dakabuku were relatively young with higher proportions of age category zero and one. The mean age of the females was less than 32 days during that period. With time proportions of higher age categories (5,6 and 7) increased and average age (in days) of flies in Dakabuku increased beyond that of the flies in Kapangani. Considering that the young adults (1-3) migrate more than old adults (4-7) and tenerals (oa and ob) (Dransfield *et al*, 1990) and that fly displacement is very low (800m-1km per day) (Vale *et al* 1984), then old flies caught in Dakabuku could have migrated from far away areas.

A higher proportion of females than males was observed in both areas. This agrees with the findings of Takken (1984) that traps catch more females than males. Tarimo *et al* (1984) also observed that the biconical trap has a bias for more females than males and Kyorku *et al* (1990), proposed that females should make more than 50% of the population in the traps since they are more than males as a result of their longevity. The slightly higher female proportion in Dakabuku therefore could have been as a result of immigrant flies into the area, since females make higher proportions of immigrant flies (Dransfield *et al*, 1990).

The low teneral proportion compared to non-teneral proportion in both areas may have been due to a bias on adults by the biconical trap. Tarimo *et al* (1984) observed that the biconical trap had a bias for adults than tenerals. The higher variation of teneral proportion from month to month could have been due to seasonal fluctuation of adult mortality as suggested by Kyorku *et al* (1990), thereby causing the percentage nulliparous to vary about an average. If such fluctuations were taking place during the period of study, then a change of teneral proportion could be observed from time to time.

Only two trypanosome species were observed in flies, *T. vivax* and *T. congolense*. In previous work done in Galana, (Njogu *et al*, 1985; Dolan *et al*, 1990) only those two trypanosome species

were identified. The lack of significant difference in infection rates in flies between Dakabuku and Kapangani could be due to the low challenge that has prevailed in Kapangani compared to other areas (Njogu *et al* 1985) and the heavy challenge in Dakabuku prior to control. Therefore control of tsetse in Dakabuku only managed to bring down the infection rates to the level at Kapangani. The increase in infection rates with age observed in the present study agrees with previous work. For instance Tarimo *et al* (1985) in their study along the Kenyan coast, observed that in areas with older flies, higher infection rates in tsetse were observed. Jordan (1976) also pointed out that since *T. vivax* and *T. congolense* infections can be acquired throughout a tsetse lifetime, highest infection rates occur in fly populations when longevity is highest. However there was a decline in infection rates beyond age categories 6 and 7. This decline may be associated with higher mortality due to trypanosome infections. Nitcheman (1990) observed that trypanosome infections in flies increased the mortality rate thereby reducing the longevity of the infected flies. Tarimo *et al* (1985) observed that infection in flies increase with age, but there is a possibility of infected flies becoming reinfected, thus resulting in a curvelinear relationship between age and infection rate. The findings in the current study agree with the curvelinear relationship of Tarimo *et al* (1985) rather than the linear relationship of Ryan *et al* (1982).

A higher infection rate in female than male flies in both areas was observed. This agreed well with the findings by Takken (1984). He observed that, although males were more susceptible to trypanosome infections than females, higher mortality rate in males was rendering them a shorter period to acquire infections, thus resulting in the lower infection rate in males compared to females. A higher infection rate in females than males was pointed out by Jordan (1976), Tarimo *et al* (1984) and Tarimo *et al* (1985).

A higher *T. vivax* than *T. congolense* infection rate was observed in flies in the current study. This observation could be associated with the simple developmental cycle for *T. vivax* compared

to *T. congolense*. It has been suggested that the hosts on which tsetse feeds influences the rates of infection by specific trypanosomes species. In areas where tsetse feeds on bovids, there are higher *T. vivax* than *T. congolense* infections while in areas where the feeds are composed of more suids, *T. congolense* infection becomes higher than *T. vivax*, (Jordan 1976; Takken, 1984; Tarimo *et al* 1984). In contrast flies have been shown to feed more on suids than bovids in some parts of Galana (Makumi per. comm.). Snow *et al*, (1988) also found that the Coastal suid-feeding tsetse population had low *T.vivax* proportion compared to those in other parts of East Africa which feed more on bovids.

Although infection rate in flies in both areas were not significantly different, a lower fly population density in Dakabuku resulted in a lower level of tsetse challenge. The findings in this study are in agreement with observations by Rogers (1979) that trypanosome transmission, which is an element of challenge, is influenced by tsetse population density. The study also agrees well with the findings by (Njogu *et al*, 1985) that trap catches for *G. pallidipes* can be used as an estimate of relative abundance of flies. In the present study deltamethrin 'pour on' technique was effectively used in controlling tsetse. This effect was followed by invasion of tsetse from the surrounding areas which maintained transmission of trypanosomes. However the rates of immigration declined with time as the sources of these flies were deprived. It would therefore seem possible to control tsetse, or even to eradicate them, using this technique as long as the method is sustained for a long period.

CHAPTER III

3. INCIDENCE OF TRYPANOSOMIASIS IN CATTLE

3.1. Introduction

During most tsetse control programmes, information collected is not sufficient for the evaluation of the success of the control of disease in livestock. Previous workers have however shown that tsetse challenge can be estimated using a sentinel herd of cattle exposed to tsetse in the field (Rogers, 1985). To estimate tsetse challenge using cattle, the number of trypanosome infective bites received by each animal per annum are considered. These are estimated using number of treatments per animal per year (berenil index) (Boyt *et al*, 1963). This estimate of challenge using berenil index is independent of fly data and therefore complements it (Claxton *et al*, 1990).

Various methods been developed for diagnosis of trypanosomiasis in cattle. These include sero-diagnosis, DNA probes and parasitological methods. Serological methods such as ELISA are sensitive but do not distinguish between existing infections and those that have been treated. The DNA probes on the other hand is sensitive and specific in identifying trypanosome species infections (Moi Yoi 1987). The technique is however not field applicable and work is going on to improve its field applicability (ILRAD 1991). The haematocrit centrifugation technique (HCT) was therefore found most suitable for this work.

Anaemia may be used as a measure of the level of disease in a sentinel herd (Anosa, 1988). Packed cell volume (PCV) gives an estimate of the anaemia (Agu and Bajeh, 1987). However in areas where other parasites co-exist with trypanosomes, levels of anaemia may not correlate well with levels of disease (trypanosomiasis) (Jeannin *et al*, 1988).

Health status in animals is also used for evaluating the success of a control programme. In areas where trypanosomiasis is controlled, improved health status is observed (Paling *et al*, 1987). The health status may be estimated using live weight gain in animals. This component of the study

was designed to investigate the various aspects of trypanosomiasis in cattle in order to evaluate the success of a control programme in the area.

3.2. Materials and Methods.

3.2.1 Study area.

See 2.2.1.

3.2.2 Experimental animals.

Two groups of cattle (Orma Boran steers) were kept both Dakabuku (experimental) and Kapangani (control). In Dakabuku 1167 steers were kept but only 100 of them were monitored weekly. In Kapangani a herd of 100 animals was initially kept, of which two died due to accidents while one was killed by wild animals. Thus only 97 animals were used for monitoring disease.

3.2.3 Monitoring infections with trypanosomes in cattle

Cattle were bled weekly by ear prick and the blood collected in heparinised capillary tubes. Blood was centrifuged for five minutes using a haematocrit centrifuge. Packed cell volume was read and the buffy coat examined for trypanosomes using the method described by Murray *et al* (1977). Trypanosome species were indentified by their morphology and movement. All infected animals were treated using intarmusculary diminazene aceturate (berenil) at a dose of 7.0 mg per kg body weight.

3.2.4 Liveweight gain

Both groups of animals were weighed every two weeks and their weights recorded.

3.3 RESULTS

3.3.1 Trypanosome infection rates in cattle

Figure 3.3.1 shows the infection rates in cattle in both areas from January to September 1991. Although trypanosome infections were monitored every week, the results presented are of a two weekly mean infection rate. In general trypanosome infection rates in cattle in Dakabuku were much lower compared to those in cattle in Kapangani. Mean trypanosome infection rates were 1.17% and 7.52% in cattle in Dakabuku and Kapangani respectively. From January (wk 53) to February (wk59), relatively high infection rates were recorded in both areas. This was followed by a decline in rates of infection in Kapangani and total lack of infections in Dakabuku at around March. Another peak of trypanosome infection was observed in cattle in both areas at around June (wk 73) and July (wk 77).

Two trypanosome species were observed, *Trypanosoma vivax* and *T. congolense*. Table 3.3.1 and 3.3.2 show species specific trypanosome infection rates in Dakabuku and Kapangani, also indicated as a two weekly mean. The number of animals diagonised is therefore assumed to be 200 in Dakabuku and 194 in Kapangani. In both areas there was a significant difference in infection rates between the two species. The mean trypanosome infection rates in cattle were 0.39% and 0.79% for *T. vivax* and *T.congolense* respectively in Dakabuku. There was a significant difference between species specific infection rates, ($p < 0.05$) and the T.v:T.c ratio was approximately 1:2. In Kapangani mean infection rates were 5.26% and 2.26% with *T.vivax* and *T. congolense* respectively. The difference in infection rate was significant, ($p < 0.05$) and the T.v:T.c ratio was approximately 2:1.

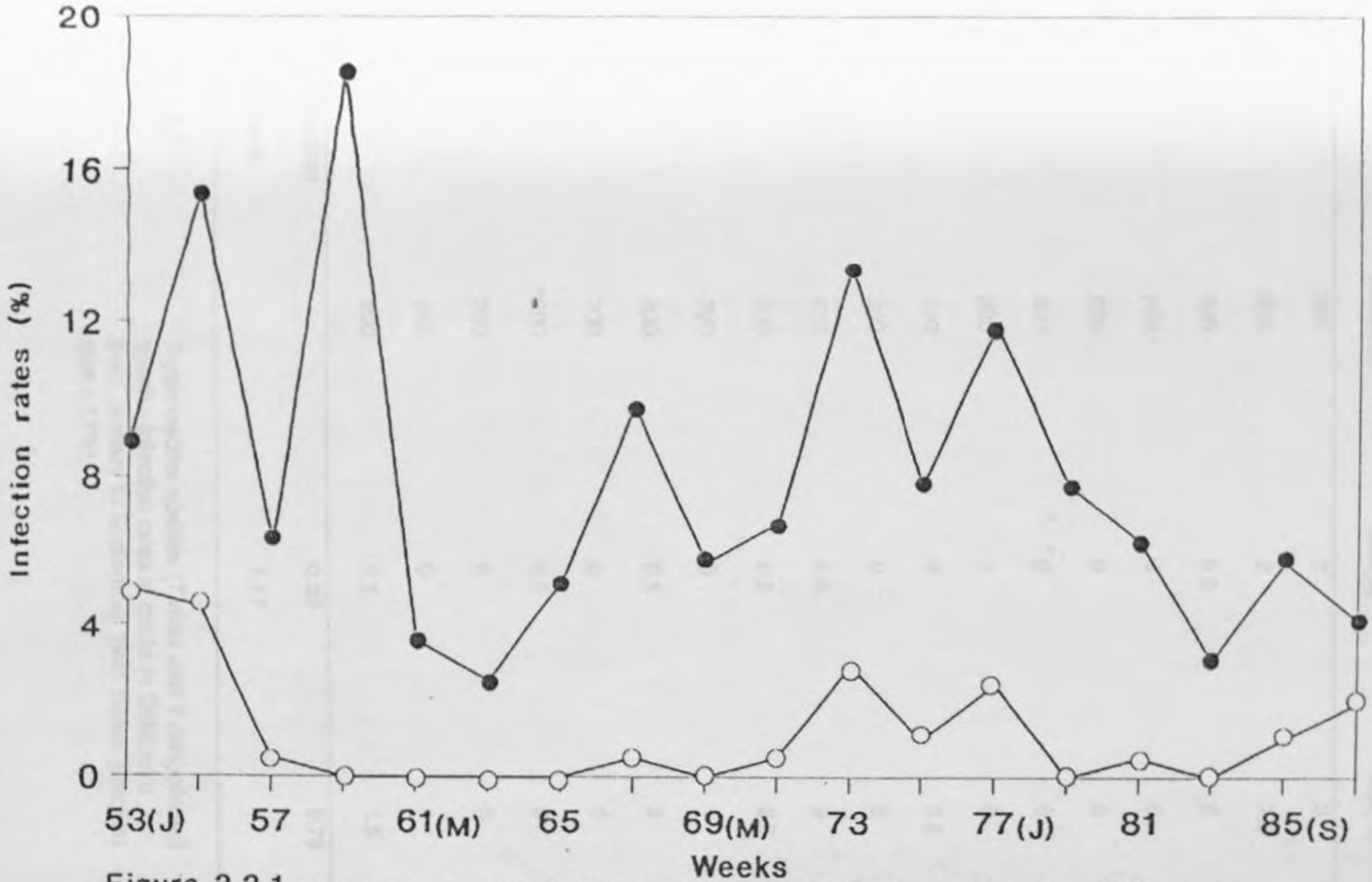

Figure 3.3.1 Trypanosome infection rates in cattle in Dakabuku (○) and Kapangani (●) from January to September 1991. (Months).

		T.vivax	*T. congolense*
Weeks	Number observed	Infection rate(%)	Infection rate(%)
J 53	200	2	3
55	200	2	2.5
F 57	200	0.5	0
59	200	0	0
M 61	200	0	0
63	200	0	0
A 65	200	0	0
67	200	0	0.5
M 69	200	0	0
71	200	0.5	0
J 73	200	0.5	2.5
75	200	0	1
J 77	200	0.5	2
79	200	0	0
A 81	200	0.5	0
83	200	0	0
S 85	200	0	1
87	200	0.5	1.5
Mean infection		0.39	0.79
Overall mean		1.17	

Table 3.3.1 Trypanosome species (*T.vivax* and *T.congolense*) specific infection rates in cattle in Dakabuku from January to September 1991 (Mean infection rate 1.17%)

Weeks	Number observed	*T.vivax* Infection rate(%)	*T. congolense* Infection rate(%)
J 53	194	7.73	1.03
55	194	15.46	0
F 57	194	5.67	0.52
59	194	16.49	2.06
M 61	194	1.03	2.58
63	194	1.55	1.03
A 65	194	3.61	1.55
67	194	2.06	7.73
M 69	194	2.06	3.61
71	194	3.09	3.61
J 73	194	8.25	5.15
75	194	3.61	4.12
J 77	194	8.25	3.61
79	194	4.12	3.61
A 81	194	4.12	2.06
83	194	3.09	0
S 85	194	3.09	2.58
87	194	1.55	2.58
Mean infection		5.26	2.26
Overall mean		7.52	

Table 3.3.2 Trypanosome species (*T. vivax* and *T. congolense*) specific infection rates in cattle in Kapangani from January to September 1991 (Mean infection rate 7.52%)

3.3.2 Berenil index

Figure 3.3.2 shows the berenil indices (number of treatments per animal per anum) in Dakabuku and Kapangani. Berenil indices in Dakabuku were relatively low compared to those in Kapangani. The difference between the two areas was significant ($p < 0.05$). High levels of berenil indices concided with high rates of trypanosome infections in cattle.

3.3.3 Packed cell volume (PCV) levels

Figure 3.3.3 show the PCV levels for both Dakabuku and Kapangani. The PCV levels were significantly higher in Dakabuku than in Kapangani ($p < 0.05$). This condition prevailed throughout the study period.

3.3.4 Average Weight

Figure 3.3.4 show the average weights of cattle in Dakabuku and Kapangani. The average weight of cattle in Dakabuku was significantly higher than that of cattle in Kapangani ($p < 0.05$). A steady rise in weight was observed in cattle in Dakabuku. In Kapangani on the other hand there were times when the average weight declined or was just stagnant. Such periods of decline or stagnation of weight gain concided with periods of high trypanosome infections.

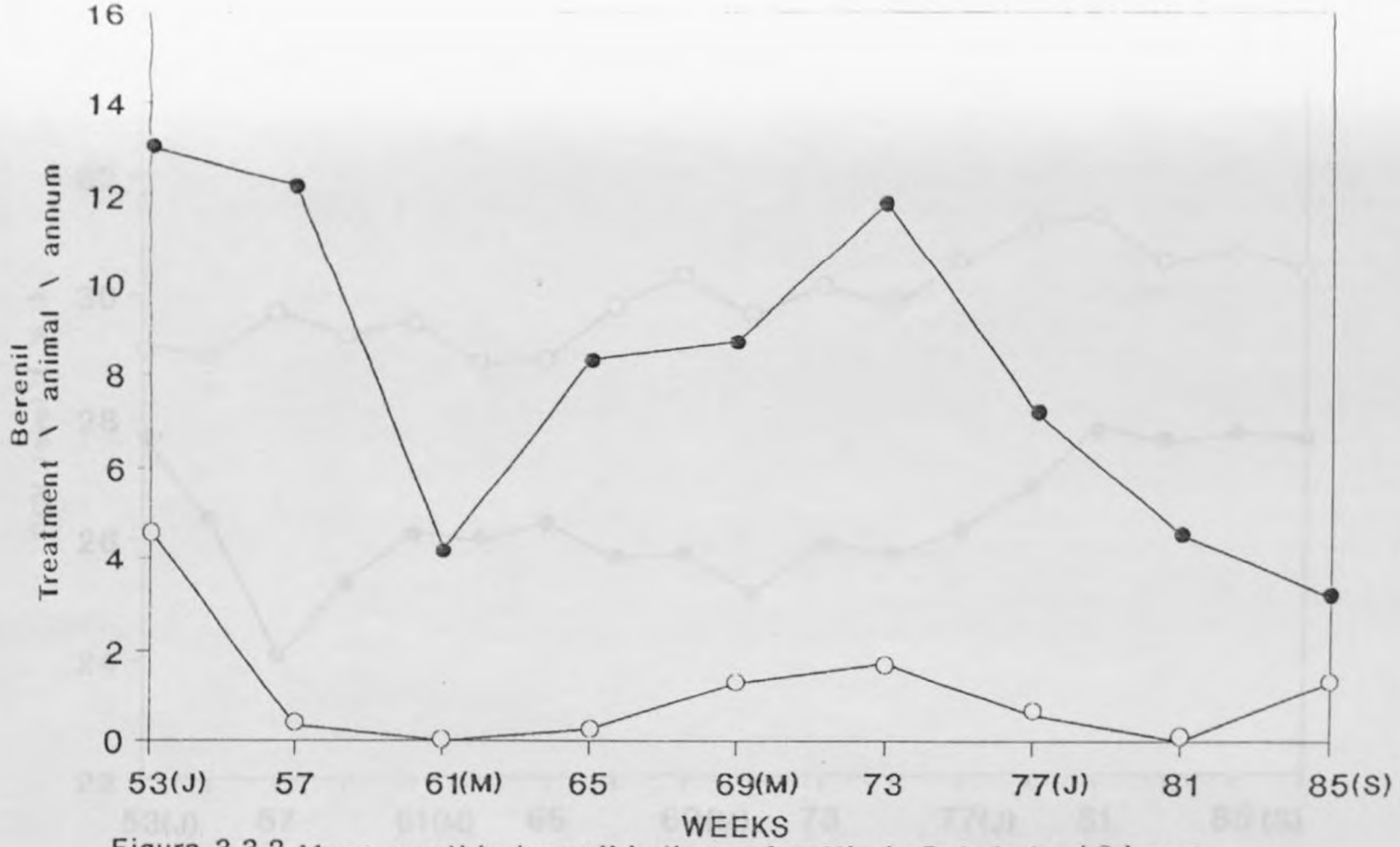

Figure 3.3.2 Mean monthly berenil indices of cattle in Dakabuku (○) and Kapangani (●) from January to September 1991.(months).

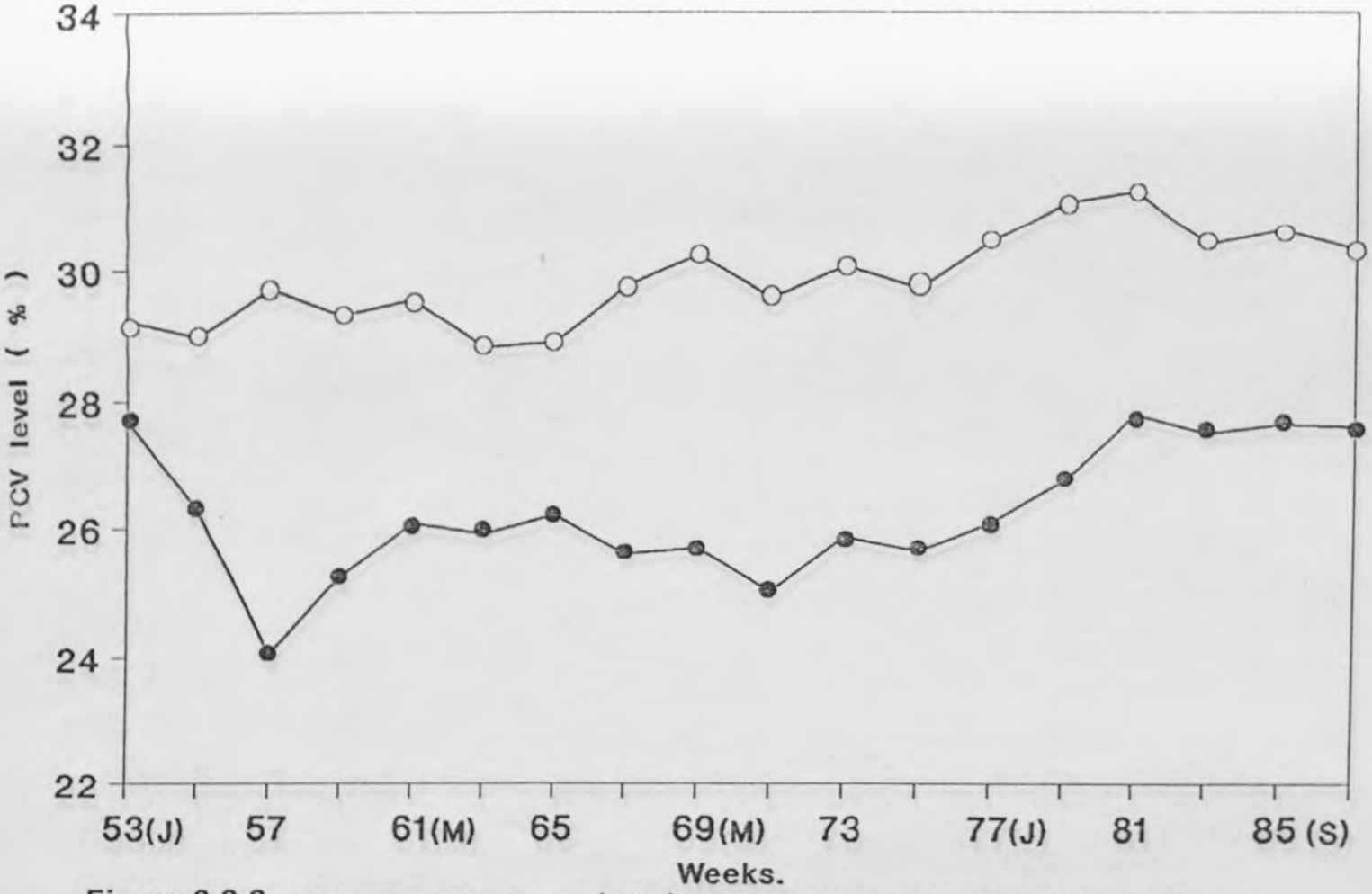

Figure 3.3.3 Packed cell volume (PCV) levels in cattle in Dakabuku (○) and Kapangani (●) from January to September 1991.(Months).

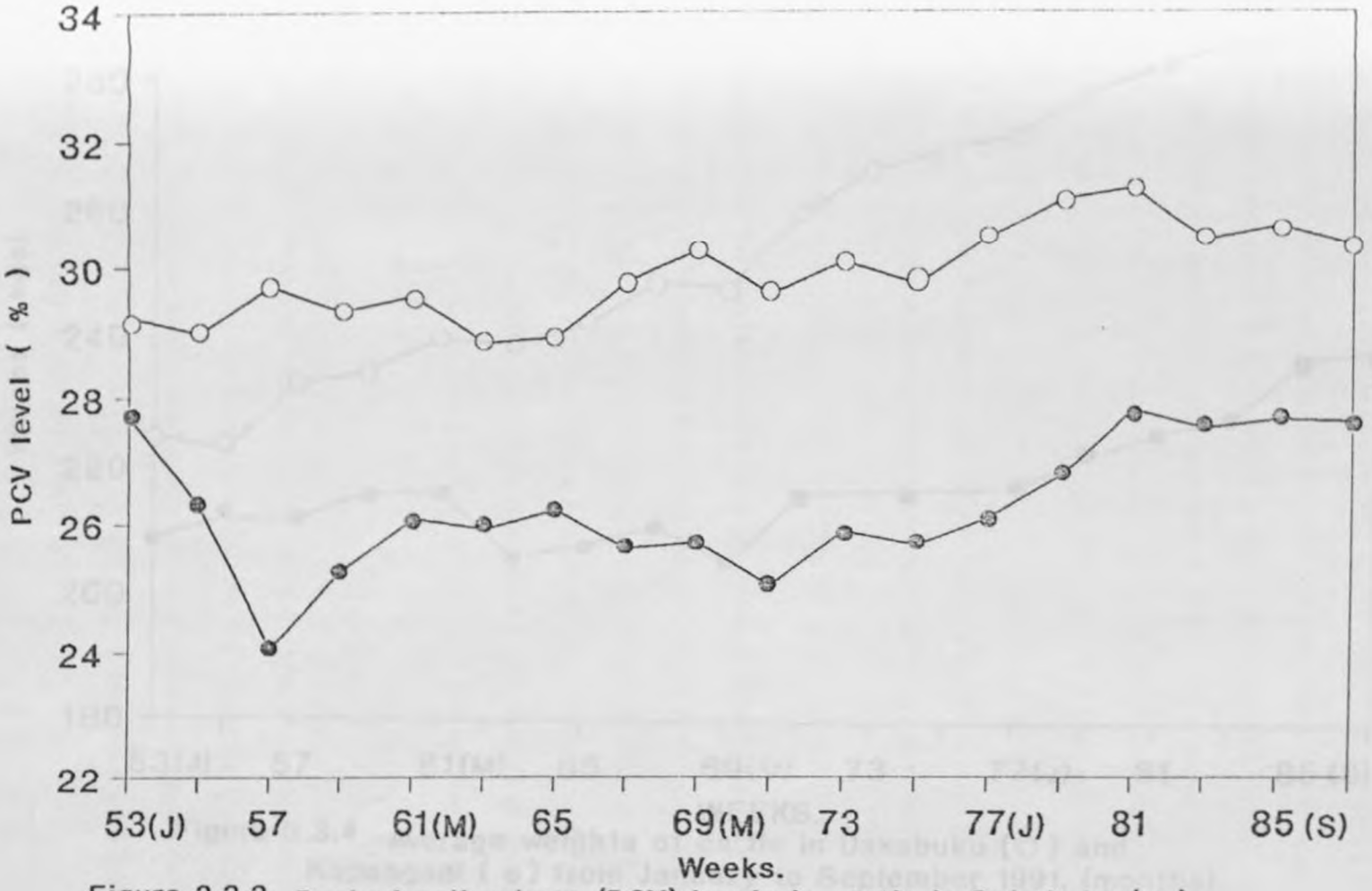

Figure 3.3.3 Packed cell volume (PCV) levels in cattle in Dakabuku (○) and Kapangani (●) from January to September 1991.(Months).

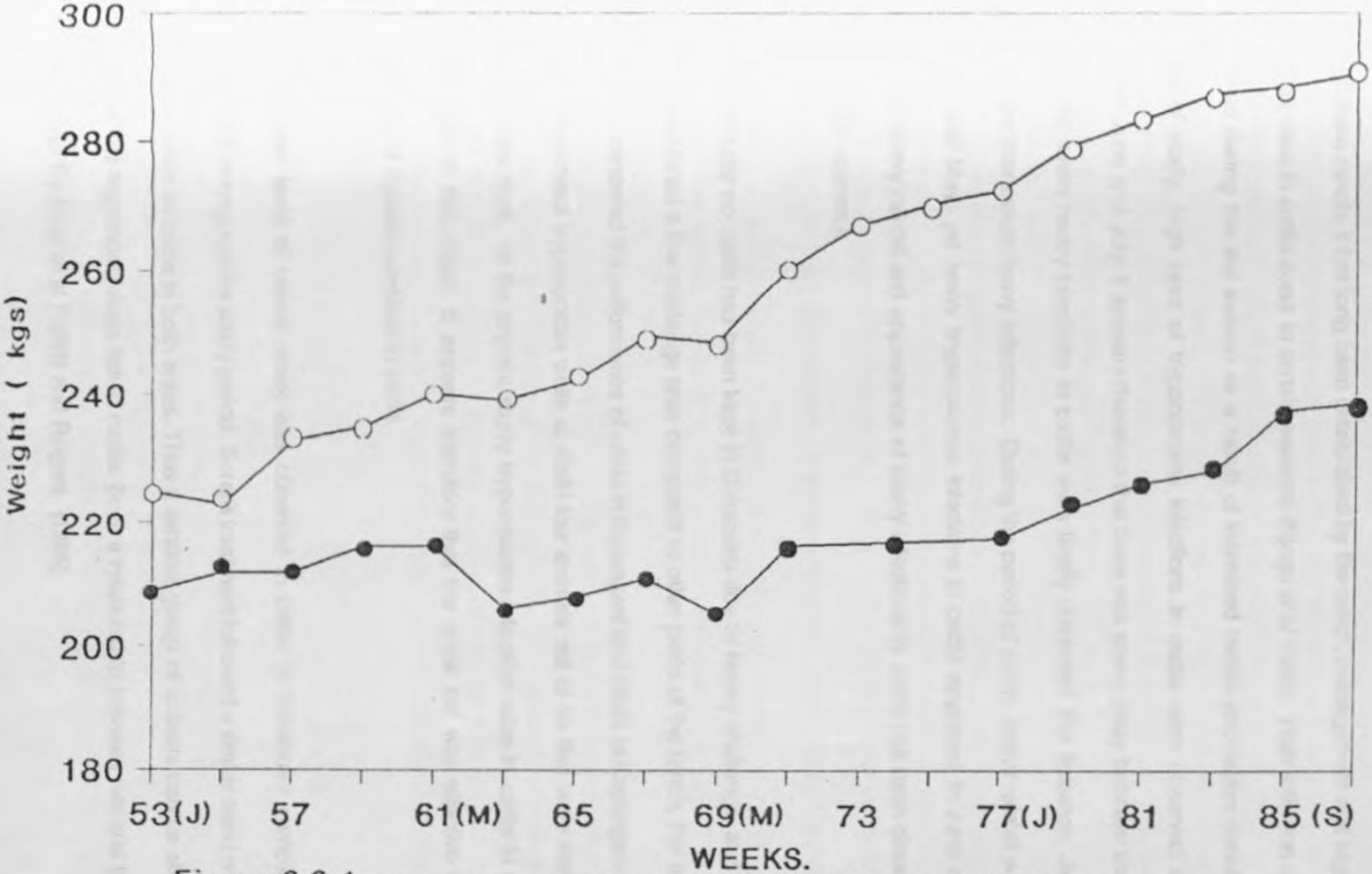

Figure 3.3.4 Average weights of cattle in Dakabuku (○) and Kapangani (●) from January to September 1991. (months).

3.4 DISCUSSION

In Galana ranch, it has long been established by the ranch management that high trypanosome infection rates in cattle occur in certain seasons (Njogu *et al* 1985). High infection rates have been observed during the wet season as a result of increased tsetse population density. During the period of study, high rates of trypanosome infections in cattle were observed in January and between June and July. It appears therefore that there was some delay between the time the rains came and when heavy infections in cattle were finally observed. For instance, January was not raining yet there were heavy infections. During the period of study, heavy rainfall was experienced in April and May, yet heavy trypanosome infections in cattle appeared in June and July. Delay between heavy rainfall and appearance of heavy infections in cattle has been observed in Galana. (Opiyo per. comm.).

Previously no cattle had been kept in Dakabuku due to heavy challenge, and Kapangani had been considered a low challenge area compared to other parts of the ranch. For intance Njogu *et al* (1985) compared the performance of cattle in Kapangani and Kisiki. In Kapangani cattle were able to survive without trypanocides while at Kisiki four animals out of six that were maintained without trypanocides died. In the present study trypanosome infection rates in cattle in Dakabuku were lower than in Kapangani. It appears therefore that the 'pour on' was effective in reducing the incidence of trypanosomiasis in cattle.

A lower level of berenil index was observed in cattle in Dakabuku compared to those in Kapangani throughout the study period. Berenil treatment followed a similar trend with trypanosome infection rates in cattle in both areas. Thus a sentinel group of animals can be effectively used to estimate the trypanosomiasis risk in cattle. Such a relationship between risk and berenil treatment was shown by Boyt *et al* (1963) and Rogers (1985).

Anaemia estimated by PCV levels, correlated well with levels of trypanosomiasis in cattle in both areas. The mean PCV decreased during heavy trypanosomes infections and increased when rates of infections were low. This was similar to the observations by Dwinger *et al* (1990) that mean PCV levels in N'Dama cattle decreased from 26.8% to 23.6% following experimental exposure to wild caught infected tsetse. Jeannin *et al* (1988) however, pointed out that in areas where trypanosomes co-exist with other parasites, PCV levels may not be a useful indicator of trypanosomiasis. It appears therefore that in Galana ranch other parasites that are present may not be as serious a menace to the health of animals as trypanosomes.

The live weight gain also followed a similar trend to the PCV. In Kapangani where trypanosome infections were high, live weight gain was lower and the mean weight of cattle in this area decreased during heavy trypanosome infections. Paling *et al* (1987) observed that in areas where trypanosomiasis had been controlled, there was improved health status in cattle. Dwinger *et al* (1990) also observed a loss of weight in one N'Dama cow and reduced weight gain in the remaining four following exposure to bites of wild caught infected tsetse.

The present study shows that cattle can effectively be kept in areas of high trypanosomiasis risk under deltamethrin 'pour on' tsetse control technique. In Galana, the trypanosome is the main parasite which hinders cattle productivity, and the severity of anaemia and live weight gain can effectively be used to estimate the trypanosomiasis risk in an area where there are no other major parasites.

CHAPTER IV

4.1 GENERAL DISCUSSION

Although mean trypanosome infection rates in tsetse in the two study areas were not significantly different (2.50% in Dakabuku and 2.70% in Kapangani) mean trypanosome infection rates in cattle in Dakabuku (1.17%) was much lower compared to that of cattle in Kapangani (7.52%). Such an observation would be expected because trypanosome transmission depends on several interacting factors rather than trypanosome infection rate in tsetse alone.

Rogers (1979) observed that trypanosome transmission is influence by tsetse population density. Therefore in Dakabuku where tsetse trap catches were low trypanosome transmission was low, and consequently the incidence of trypanosomiasis in cattle was low. The findings in this study agrees well with findings by other workers that tsetse population density influences trypanosome transmission (Noireau *et al* 1990 and Gouteux *et al* 1990. Tsetse population density was estimated using trap catches (Njogu *et al,* 1985) which was then used to estimate trypanosome transmission or tsetse challenge. Tsetse challenge index gave a better picture for the occurrence of disease in cattle than trypanosome infection rates in tsetse alone. Trap catches is therefore a reasonable measure of *G. pallidipes* population density.

Another factor that influences trypanosome transmission to cattle is infection rate in tsetse. The trypanosome infection rate in tsetse is influenced by the average age of the population (Jordan 1976, Tarimo *et al* 1984). When flies live long enough to allow trypanosome to mature, the population acquires a high infection rate. From January to March, flies in Dakabuku were on average below 35 days and the trypanosome infection rate was also relatively low. During the rest of the period, flies were on average equal to or older in age than those in Kapangani, and the trypanosome infection rate was not significantly different. It appears therefore that the longevity of

flies had as much influence on trypanosome infection rates in tsetse as population density (population density was measured by trap catches).

The repellancy nature of deltamethrin to tsetse might have influenced the trypanosome transmission to cattle. Abiola *et al,* (1990) observed that deltamethrin treated cattle attracted five times less flies as the untreated group. This may therefore mean that less flies were feeding on cattle in Dakabuku compared to those feeding on cattle in Kapangani.

In both areas a higher *T. vivax* (1.64% in Dakabuku and 2.62% in Kapangani) infection rate than *T. congolense* (0.87% in Dakabuku and 0.67% in Kapangani) was detected in tsetse. However in Dakabuku *T. congolense* infection rate (0.79%) in cattle was significantly higher than *T. vivax* infection rate (0.39%). The *T. vivax* : *T. congolense* (T.v:T.c) ratio was approximately 2:1 in tsetse and 1:2 in cattle. In Kapangani *T. vivax* infection rate was significantly higher than *T. congolense* infection rate in both tsetse and cattle. However the T.v:T.c ratio was approximately 3:1 in tsetse and 2:1 in cattle. This indicates an increase in *T. congolense* infection rate from tsetse to cattle. This could mean that the method of identification was not efficient and that some *T. congolense* parasites in tsetse were missed out all together. The method used for identifying trypanosome in tsetse in this study (Llyod and Johnson, 1924) was developed long ago and has not been improved since. Other methods available such as passaging in laboratory animals may not be applicable in field studies. Besides, *T. vivax* and some *T. congolense* strains do not develop in mice. A field applicable method of identification of trypanosome species in tsetse needs to be developed.

The other possibility is that different trypanosome species have different infectivity rates in cattle. Thus *T. congolense* may be establishing in cattle with more ease compared to *T. vivax.* Njogu *et al* (1985) suggested that there is a possibility of development of resistance to *T. vivax* infection in cattle in Galana. If such a resistance exists, then the change in the ratio of trypanosome

species from tsetse to cattle could be explained. However the infectivity rates of trypanosome in tsetse and cattle in the wild should be investigated to enable a better understanding of the relationship in infection rates between tsetse and cattle.

Although the 'pour on' technique was effective in reducing the incidence of trypanosomiasis in cattle, it was ineffective in the control of invasion by immigrant tsetse. The changes in tsetse population density and average age observed during the study period indicates a possibility of re-invasion. In Dakabuku low trap catches and low average age of flies observed from January to March suggests that only resident flies were present in the area, and that there was a high mortality rate especially of old flies. Rogers and Randolph (1984) observed that there are proportionately large numbers of young flies relative to older ones in a tsetse population which is relatively stable but experiencing high mortality.

Following the long rains in April tsetse trap catches increased and the population was made up of all age categories. This was due to improved environmental conditions which enhanced emergencies of tenerals and invasion by immigrant tsetse. Dransfield et al (1990) observed that heavy rates of immigrations occurred during or after the rains. Such immigrant tsetse were responsible for the increased trap catches which were composed of all age categories of tsetse observed from April to June. Even after the rains population in Dakabuku continued to be maintained by immigrant tsetse which were being eliminated before they could larviposit. The tsetse population was on average older in Dakabuku compared to that in Kapangani. Hargrove and Langley (1990) observed that the average age of flies doubled as a result of high death rate of juveniles and high immigration rate of adults. Flies caught in Dakabuku during and the after the rains were mainly immigrants. It would therefore be better to put a barrier system using either traps or targets during a control programme. Such barriers would prevent re-invasion of flies into the control block.

4.2 Conclusion

In conclusion therefore it was noted that:

Deltamethrin 'pour on' technique is effective in the control of tsetse population and consequently the reduction of incidence of trypanosomiasis in cattle. Tsetse population reduction may be followed by invasion from the surrounding areas, particularly by old flies which are able to maintain transmission but at a lower level. It is therefore suggested that during tsetse control programmes using 'pour on' technique, barriers should be used to prevent re-invasion by immigrant tsetse. That the control technique is easy to maintain makes it sustainable for a long period enabling total eradication of the flies over large areas. Since animals are being used as targets, then the question of how the area will be utilized after the control does not arise.

This study supports the use of trap catches as an estimate for tsetse population which can then be used to estimate tsetse challenge in an area.

Investigations to establish the infectivity rates of different trypanosome species in tsetse and cattle in the wild should be done. This would enable a better understanding of the relationship between trypanosome infection rates in the vector and the host.

The method of trypanosome identification in tsetse in the field should be improved or a more efficient field applicable method should be developed. This should enable identification of trypanosome species to be more accurate and specific rather than use of location of the parasite in the vector.

Recommendations

Deltamethrin 'pour on' tsetse control technique should be introduced in livestock keeping areas where tsetse and trypanosomiasis ares a problem. This was arrived at after observing the following points;

1. Deltamethrin is effective in reducing tsetse population and consequently the incidence of the disease.
2. The formulation controls both ticks and tsetse.
3. The fact that cattle, already existing in the area are used as targets, then the method does not incur high cost in terms of overhead in order to begin the control and the problem of land utilisation after the control does not arise.
4. The method is easy to apply and therefore it can be sustained over a long period resulting to total erradication of tsetse.

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Date	Male	Female	Total Catch	Fly/Trap/day
21/1/91	114	129	243	15.19
5/2/91	229	304	529	33.06
19/2/91	30	22	52	3.25
5/3/91	13	16	29	1.8
19/3/91	4	9	13	0.8
4/4/91	27	90	117	7.3
18/4/91	15	48	63	3.9
30/5/91	28	46	74	4.6
14/5/91	24	39	63	3.9
28/5/91	116	187	294	18.4
13/6/91	50	118	168	10.5
26/6/91	113	142	255	15.9
10/7/91	29	73	102	6.4
26/7/91	26	39	65	4.1
9/8/91	10	15	25	1.6
21/8/91	18	8	26	1.6
11/9/91	31	21	52	3.25
26/9/91	12	11	23	1.44

Appendix I Glossina pallidipes trap catches in Dakabuku from January to September, 1991.

Date	Male	Female	Total Catch	Fly/Trap/day
21/1/91	206	268	474	39.50
5/2/91	104	200	304	25.33
19/2/91	87	148	235	19.6
5/3/91	81	275	356	29.7
19/3/91	500	1235	1735	144.6
4/4/91	484	952	1436	119.67
18/4/91	211	213	424	35.3
30/5/91	186	161	347	28.9
14/5/91	293	354	647	53.9
28/5/91	510	886	1386	116.3
13/6/91	48	79	127	10.6
26/6/91	238	414	652	54
10/7/91	70	120	190	11.9
26/7/91	43	66	109	9.1
9/8/91	107	169	276	23
21/8/91	63	76	139	11.6
11/9/91	36	24	60	4.83
26/9/91	48	72	120	10

Appendix II Glossina pallidipes trap catches in Kapangani from January to September, 1991.