SCREENING OF SOME NIGERIAN PLANTS FOR MOLLUSCICIDAL ACTIVITY

BY

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D E C L A R A T I O N

This is to certify that I carried out the work reported in this thesis in the Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria. The project was supervised by Professor R.A. Ogunsusi and Dr. V.C. Ogbogu both of the Department of Parasitology and Entomology and Professor N. Nwude of the Department of Physiology and Pharmacology.

The works of other investigators in related fields are specifically acknowledged by means of references. No part of this thesis has been submitted elsewhere for a degree or diploma.

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CERTIFICATION

This thesis by Santaya Larit KELA entitled "Screening of some Nigerian Plants for Molluscicidal Activity" meets the requirements for the award of the degree of Master of Science, Ahmadu Bello University (ABU) and is approved for its contribution to scientific knowledge and literary presentation.

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D E D I C A T I O N

This thesis is dedicated to my daughter Zipporah Kela, my wife Mrs. Ofrah Kela, and to the memory of my late father, Mr. Kela Larit.

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A B S T R A C T

A total of 25 Nigerian plants used locally for different medicinal and domestic purposes were extracted with cold methanol before evaporation to get the methanolic (MEOH) extracts and distilled water [used after filtration as unevaporated crude water (UECW) extracts or after filtration, rotary evaporation and redissolving as evaporated crude water (ECW) extracts]. When they were tested for molluscicidal activity, extracts of 18 (72%) of the plants were active on laboratory reared adult Lymnaea natalensis Krauss. The ECW method produced extracts that were active in 9 (36%) of the 25 plants, the MEOH method produced extracts that were active in 13 (52%) of the 25 plants while the UECW method produced extracts active in 16 (64%) of the 25 plants.

Probit analysis of the lethal concentration (LC) values of molluscicidal plants showed that the ECW extracts of Aristolochia albida, Kigelia africana, Sclerocarya birrea and Vetiveria nigritana were significantly more toxic than those of the MEOH and UECW extracts. The MEOH extracts produced by Boswellia dalzielii, Gnidia kraussiana (=Lasiosiphon

kraussianus), Pseudocedrela kotschyi and Ziziphus abyssinica were significantly more toxic than the ECW and the UECW extracts, while the UECW extracts of Acacia nilotica, Balanites aegyptiaca, Blighia sapida, Detarium microcarpum, Nauclea latifolia, Polygonum limnatum and Parkia clappertoniana (=Parkia filicoidea) were significantly more toxic than the ECW and the MFOH extracts. The UECW extract of Securidaca longipedunculata had about the same toxicity with the MEOH extract, both of which proved significantly more toxic to adult snails than the ECW extract.

Further toxicity tests with the UECW extracts of 17 plants on young L. natalensis showed that their susceptibility to these extracts also differed. A. nilotica, A. albida, G. kraussiana, Ximenia americana and V. nigritana which had activity on adult snails were non-toxic to young snails, while Cissampelos mucronata which appeared non-toxic to adult snails was molluscicidal to young snails.

Computed X^2 values of all molluscicidal plants together with copper sulphate ($CuSO_4$) controls were

non-significant for heterogeneity.

Poisoning with extracts caused adult snails either to retract into the shell or to become swollen and extended from the shell opening, expelling or not expelling haemolymph. These were attributed to the mode of action of the extracts. Peculiar protective behavior of L. natalensis to avoid contact with test solutions was also observed especially with sub-lethal doses of extracts.

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ABBREVIATIONS

ABU	-	Ahmadu Bello University
$CuSO_4$	-	Copper Sulphate
ECW	-	Evaporated Crude Water
F	-	Fulani
Fig	-	Figure
Figs	-	Figures
H	-	Hausa
I	-	Igbo
l	-	Litre
LC	-	Lethal concentration
MEOH	-	Methanol or methanolic
mg/l	-	Milligram per litre
NaPCN	-	Sodium pentachloropenate
No.	-	Number
Pl	-	Plural
ppm	-	parts per million
S	-	Samban
T	-	Tangale
UECW	-	Unevaporated crude water
WHO	-	World Health Organisation
W/v.	-	Weight per volume
Y	-	Yoruba

DEFINITION OF TERMS

Molluscicide - A substance that is poisonous or lethal to molluscs (e.g. snails). It may be synthetic or derived from plants.

Molluscicidal - **Referring to a substance that is poisonous and lethal to molluscs (e.g. snails)**

Cercaricidal - **Referring to a substance that is lethal and poisonous to cercariae.**

Ovicidal - **Referring to a substance that is poisonous and lethal to eggs.**

Piscicidal - **Referring to a substance that is poisonous and lethal to fish.**

Toxicology - The study of poisons and their effects on living organisms.

Toxicity - The degree of virulence produced by poisons or toxicants.

Lethal concentration (LC) - This is the concentration of a substance that is required to kill a certain percentage of the organisms within a particular period of time.

LC_{50}	-	This is the concentration of substance that is required to kill 50% of the organisms within a particular period of time.
Zoonoses	-	Those diseases and infection, which are naturally transmitted between vertebrate animals and man.
Zoonotic	-	Pertaining to zoonoses.

CHAPTER ONE

I N T R O D U C T I O N

The digenetic trematodes comprise a large group of endoparasites variable in size and shape. In their hosts, these parasites are found practically in all the major organs causing in varying degrees, disorders of medical and veterinary importance. Quite a considerable number of them are of zoonotic importance (Ulmer, 1975). Most of the important members belong to the family Schistosomatidae and Fasciolidae.

From the standpoint of development and life-history, the digenetic trematodes possess by far the most complex developmental cycles among the animal kingdom. In a typical digenetic life-cycle, they develop through a succession of stages utilizing two, three or more hosts: one being the definitive host and the other(s) serving as the intermediate host(s). In the intermediate host, the parasite assumes various larval forms each of which develops asexually from the preceeding generation. It is only in the definitive host that sexual reproduction occurs. However, what ever the

variation in life-cycle, they have one feature in common i.e. all require a mollusc as the only or one of the intermediate host(s). It is in this host that the final product of asexual reproduction - the cercariae infective to the definitive host or the cercariae which encyst to give metacercariae infective to the definitive hosts are produced. Thus, the occurrence of trematode disease is dependent on the presence of biotypes suitable for the development of the molluscan intermediate hosts and as such associated with specific ecological niches.

Many fresh water and amphibious snails have been identified as intermediate hosts of digenetic trematodes of medical and or veterinary importance. It has been observed that there is a high degree of specificity among trematodes in general for the snail intermediate hosts (Wright, 1973; Malek and Cheng, 1974).

The family Schistosomatidae includes the genus Schistosoma which in turn includes several species parasitic in the blood vessels of man and domesticated animals. Human schistosomiasis, a disease caused by infection with Schistosoma species is considered by WHO (1965) to be the second most important human

parasitic disease, estimated to affect about 200 million people mostly in the tropics (WHO, 1980). Schistosomes occur almost in all domesticated animals and are increasingly being recognised as important pathological agents of livestock.

Trematodes belonging to the family Fasciolidae are large flukes parasitising and causing damage to the liver of herbivores and sometimes man. Fascioliasis (liver rot) due to Fasciola gigantica and Fasciola hepatica is considered the most important trematode infection of domesticated animals. The economic losses resulting from fascioliasis are enormous (Oakley, 1978), and the increasing frequency of the disease appears to be associated with intensive agricultural practices including continuous grazing and the feeding of cut foliage from infected areas (Alicata, 1964). As well as fascioliasis, numerous other snail-borne fluke diseases occur especially in the tropics. Some of them are of zoonotic importance. Among the better known of these are species of Dicrocoelium, Heterophyes, Paragonimus and Paramphistomum.

Thus, the importance of snails in the propagation of important fluke diseases of man and his domesticated stock cannot be over-emphasized.

The aims of the present study therefore are:

(a) To screen some Nigerian plants for molluscicidal activity.

(b) To determine their molluscicidal activity on 12-week (adult) Lymnaea natalensis.

(c) To evaluate the spectrum of activity of plant extracts molluscicidal on L. natalensis at 100 parts per million (ppm).

(d) To compare the toxicity of extracts with copper sulphate ($CuSO_4$).

(e) To determine the molluscicidal activity of Unevaporated crude water (UECW) extracts on 2-week (young) L. natalensis.

The objective was to discover indigenous plants that may be readily available within the reach of most rural communities, and probably cheaper for use in control of snail-borne diseases.

CHAPTER TWO

LITERATURE REVIEW

2.1 Control of Snail-Borne Diseases

Compared with many other parasitic diseases, little overall progress has been made in the control of snail-borne diseases both in man and livestock. It is only in a few areas that substantial progress has been made. The objectives of control of any disease may be simple containment of the spread of infection, a reduction in morbidity or a significant reduction in a transmission resulting in decreased morbidity, severity and prevalence. Control methods often used include chemotherapy, health education of the human population, biological, environmental, chemical and integrated control methods of snail intermediate hosts.

2.1.1. Chemotherapy

Mass chemotherapy involves treatment of all infected people within the population with appropriate drugs at specific dosage and frequency of administration (WHO, 1960, 1980). This approach has been used in a

number of schistosomiasis control programmes as summarised by WHO (1980) which resulted in the decrease in prevalence. According to WHO (1980), Niridazole in combination with tartar emetic in Egypt reduced morbidity from 45.7% in 1968 to 6.2% in 1977 while Niridazole together with hycanthone were found to give good results in Swaziland and in Tunisia, 91.9% success was reported over an 8-year control period, while oxamniquine in Venezuela gave 92% curative measure over the same period. Inspite of these encouraging results, this method has some disadvantages. Firstly, although output of eggs from infected individuals are reduced which in turn reduces transmission, reservoir hosts may directly or indirectly pollute the water with eggs of the parasites and thus maintain a high level of endemicity (Malek & Cheng, 1974). Secondly, the drugs have some side-effects on the infected individuals. Niridazole and hycanthone are potential carcinogens, and Niridazole also has a cytogenetic action on spermatogenesis (WHO, 1980). Oxamniquine produces dizziness, drowsiness, headache, vomiting and diarrhoea (Davis, 1973). In the past chemotherapy for livestock fascioliasis involved the use of carbon tetrachloride which was later abandoned due to its poisonous nature. Thirdly, most of the drugs are

expensive and may not be affordable to poor countries. For example, hexachloroethane and hexachlorophene used in the treatment of cattle and sheep fascioliasis (Soulsby, 1982), apart from not always being available are also costly.

2.1.2. Health Education

Health education has been integrated into all successful schemes of control of parasitic diseases. In Egypt, Sudan and Zimbabwe. Where great stress has been put on health education in an attempt to control schistosomiasis, the strategy was directed at the population at risk, the five-year old age group (Gana, 1979; Pugh, 1979). This took the form of posters and lectures. However, this met with considerable difficulties due to high illiteracy rate. According to WHO (1980), effective health education programmes for schistosomiasis control should promote active community participation, establishment of water supply through self-help projects and communal cooperation with health authorities in reducing contact with infested water. However, in most localities at risk, it may be impracticable to recommend this due to the fact that couple with poor finance, the very existence of

the community depend on the use of infested water bodies for house-hold uses and cultivation of crops.

2.2 Snail Control

All methods used to prevent or eradicate snail-borne diseases depend upon interrupting the life-cycle of the parasite in such a way as to break transmission. Evidence indicates that snail control is the most effective single measure of control of snail-borne diseases as the snails represent the weakest link in the life-cycle of the parasites (WHO, 1960). However, complete eradication of the snail intermediate hosts may be extremely difficult because of their high intrinsic rate of proliferation, dispersion capabilities and genetic variation (WHO, 1980); but there is the possibility that transmission could be prevented by reducing the snail population density below a certain threshold. Goffman and Warren (1970) observed that if the density of susceptible snails falls to the critical level, then the disease will decline. Some degree of snail control may be achieved by a wide range of measures involving biological, environmental, chemical and integrated approaches.

2.2.1. Biological Control of Snails

Biological control is based on stress produced by other organisms which compete with, prey on or parasitize the snail intermediate hosts. Predators and competitor snails such as Lininogeton fibri, Marisa cornuarietis, Tereba granifera and Pomacea haustrum compete as voracious feeders with adult and also ingest egg masses and young Biomphalaria glabrata in Puerto Rico (McMullan, 1973). Fish e.g. Clarias gariepinus and Tilapia and ducks are other potential agents in East Africa and Nigeria.(Cowper, 1971). Similarly, parasitic fungi, leeches, nematodes, oligochaetes and trematodes serve as control agents against snails of the genera Austrolorbis, Biomphalaria, Bulinus and Helisoma (Malek and Cheng, 1974). The possibility of using schiomyzid larvae to control Lymnaea snails has been reported by Berg (1964). According to this worker, larvae of this insect prey exclusively on Lymnaea snails than those of related groups Phernaea dorsata, Sepedon macropus and Pheidole megacephala.

One drawback in the use of biological control in reducing snail population is that they have been mostly based on the results of laboratory experiments.

Under laboratory conditions however, the biological balance is disturbed to the disadvantage of the snail, and, therefore in nature where this imbalance does not occur, it seems unlikely that these parasites and predators are effective in exterminating the snails. There may be, however, some reduction in the population density.

2.2.2. Environmental Control of Snails

This is effected through altering the habitat necessary for establishment of snail colonies and thus either eradicating them or considerably reducing the size of the population. Some of the methods used is to drain or fill in and dry out all unnecessary bodies of water; increasing the speed of flow of streams; clearing vegetation from banks and provision of concrete linings to irrigation cannals.

This technique has been particularly effective in Palo, Leyte, Philippines and Japan where engineering and improved agricultural methods in endemic foci eliminated many snail colonies with 95% reduction of total snail population (McMullen, 1973). Stool assay of the local population made before and two years after control was started showed a decrease in prevalence

in all age groups; with 77% success in the under five years' age group. Similarly, in Iraq, Kenya, Ghana, and Puerto Rico, well-designed and constructed irrigation and drainage systems, good water management, careful maintenance of canals, especially weed control and improved agricultural practices successfully reduced snail populations (WHO, 1980). However, the drawback in the use of this technique is that snails can withstand long periods of dessication and are able to repopulate the habitat within a short period after water has returned.

2.2.3. Chemical Control of Snails

Chemical control employs several synthetic molluscicides such as Niclosamide (Bayluscide), Copper sulphate ($CuSO_4$), sodium pentachlorophenate (NaPCP) (WHO, 1965). Control by molluscicides is a rapid and efficient means of reducing or eliminating snail population and has been recommended to be among the method of choice for snail control programmes (McCullough et al., 1980). Niclosamide and NaPCP are both molluscicidal and ovicidal with encouraging results obtained in field control programmes in Egypt, Sudan, Arabia, Swaziland,

Tanzania and Tunisia (McCullough et al., 1980; WHO, 1980). They are also selective in action by not affecting non-target organisms (WHO, 1960). One of the problems associated with the use of molluscicides is that of resistant strains of snails developing as pointed out by (WHO, 1980). Furthermore some of them e.g. NaPCP are irritating to the handler. The activity of NaPCP is also known to be reduced by bright sunlight hence reducing its effectiveness under tropical conditions (WHO, 1960). $CuSO_4$, though less piscicidal, is corrosive to equipment, ineffective at high pH, non-ovicidal and readily absorbed by soil and organic matter (Ritchie, 1973).

2.2.4: Integrated Control of Snail-borne Infections

Integrated control employs a combination of two or more of the current measures to meet the basic health needs of the local people. For example, chemotherapy may be combined with snail control, supply of portable water and health education, to achieve better results. This approach offers the best way in snail control programmes because it utilises the advantages and minimises the disadvantages of other control methods.

2.2.5. Plant Molluscicides

In view of the grave disadvantages of using chemical molluscicides and limitations of other approaches, it is clearly important that serious consideration be given to molluscicides of plant origin. This is an aspect of snail control that has of recent been receiving greater attention since Lemma (1965) observed high mortality of Schistosome-transmitting snails in natural bodies of water where Phytolacca dodecandra (Endod) had been used.

In Nigeria, evaluation of vegetable molluscicides embracing many traditional medicinal plants has been carried out by Adewumi and Safowora (1980) who showed that 23 (12.7%) of the plant extracts they screened were molluscicidal i.e. giving 100% mortality of laboratory bred Bulinus (Physopsis) globosus. They also observed that molluscicidal activity was not limited to or more pronounced in any particular family or morphological part of the tested plants. Another preliminary investigation on Ambrosia maritima has also been reported by Ebele (1981). Water extracts of this plant at 500 ppm were found to be lethal to B. globosus. Similarly, Alternanthera sessilis, a

soap making aquatic plant commonly found in fresh water has been reported to be lethal to B. globosus (Ndifon, personal communication).

An extensive laboratory and field evaluation of the aqueous and methanolic extracts of Tetrapleura tetraptera was carried out by Adewumi et al. (1980) in a Schistosomiasis control project at Fasina and Adun-Abon, Western Nigeria. The methanolic extracts gave encouraging results of being stable under field conditions with little mammalian toxicity and no phytotoxicity. In another field trial it was found that Calliandra portoricensis though molluscicidal was also highly piscicidal (Adewumi & Marquis, 1981).

A host of other tropical plants either those used in African traditional medicine or species closely related to them have been found to be molluscicidal. The fruits of Balanites aegyptiaca used as food in Nigeria and other African countries (Dalziel, 1937) and as a fish poison (McCullough et al., 1980) was shown to have some activity against B. planorbis (Archibald, 1936) and B. glabrata (Plank, 1945). Its activity on B. (P.) globosus was confirmed in Nigeria by Adewumi and Safowora (1980). Another closely related plant Balanites maughmii was lethal

to B. (P.) africanus and L. natalensis in South Africa (Wagner, 1936).

Acacia, Pithecellobium, Parkia and Prosopis species the seed of which give high quality protein and are consumed throughout tropical Africa (Dalziel, 1937; Felker & Bandurski, 1979) exhibit toxicity to snails (Kloos & McCullough, 1982). The leaves of Ximenia americana (Adewumi & Safowora, 1980), Dichrostachys glomerata (Jordin, 1970) the fruits of which are eaten in tropical Africa, and the leaves of Lophira alata, sought for the oil in the nuts are also lethal to snails (Kloos & McCullough, 1982). The shell of the cashew nut (Anacardium occidentale) in an hexane extract, killed young and adult B. glabrata and their eggs at very low concentrations (Pereira & Soine, 1974; Sullivan et al., 1982).

Other plants with molluscicidal properties include Phytolacca dodecandra (Endod) which is used as soap and traditional medicine in Ethiopia (Kloos, 1976) and Sapindus saponaria (Mozley, 1939; Medina & Woodbury, 1979; McCullough et al., 1980), Polygonum senegalense (Dossaji et al., 1977), Entada phaseoloides (Yasuraoka et al., 1977), Schima argentea, Swartzia madagascariensis (Mozley, 1939), Calliandra

portoricensis (Adewumi & Sofowora, 1980) which is used as fish poison. The seed of Croton macrostachys and Croton tiglium used as a purgative and antihelminthic in Sudan were found to be molluscicidal (Daffala & Amin, 1976). Similarly, Ambrosia maritima used as an antispasmodic in colics, as a diuretic (Sherif & El-Sawy, 1962a) and as a remedy for haematuria in S. haematobium infections in Egypt (Kloos & McCullough, 1982) have been used in community-level snail control programmes (Sherif & El-Sawy, 1962b,c). Withania sammifera, a household medicine in Ethiopia (Kloos, 1976) which also contain an anti-tumor and anti-arthritic steroid lactone (Fuegner, 1973) is a potential plant molluscicide to B. globosus in Ethiopia (Kloos & McCullough, 1982).

Watt and Breyer-Brandwizk (1962) have pointed out that few plant species screened for molluscicidal activity have already been studied chemically and pharmacologically. Some of the traditional medicinal plants have been studied and the chemical basis of their action outlined. For example, Ambrosin, damsin and tribromodamsin are responsible for the molluscicidal action of Ambrosia maritima (Abu-Shady & Soine, 1953). Similarly, flavonol glycoside, a cynogenic compound is the active material of Polygonum senegalensis

(Dossaji et al., 1977; Hostettmann et al., 1982), while the triterpenoid saponin, oleanolic acid glycoside has been reported to be the active material responsible for the molluscicidal action of Phytolacca dodecandra (Parkhurst et al., 1974; Hostettmann et al., 1978). Other plants whose molluscicidal activity are due to saponins include Derris elliptica, Agava sisalana, Balanites aegyptiaca, Entada phaseoloides, Swartzia madagascariensis, Schima argentea and Sapindus saponaria (McCullough et al., 1980). In Egypt, Bergapten in Amni magus has been shown to be as active as NaPCP, and safe to handle (Abdulla et al., 1977).

The vast majority of the world's screened plant molluscicides were mainly tested on Schistosoma-transmitting snails (Kloos & McCullough, 1982) with only a little work being done on Fasciola-transmitting snails. This may be partly due to lack of awareness on the increasing economic loss due to fascioliasis (Babalola & Schillhorn van Veen, 1976; Oakley, 1978; Alonge & Fasanmi, 1979; Kela, 1982) or the assumption that such plants screened on Schistosoma-transmitting snails may also have activity on Fasciola-transmitting snails. This may not be so as Lymnaea truncatula (Taylor, 1964) and some strains of L. natalensis

are semi-aquatic and may exhibit different protective behavior in test solutions from the aquatic Biomphalaria and Bulinus snail intermediate hosts of schistosomiasis. Moreso, different species of snails vary in susceptibility to different molluscicides (Lemma, 1970; Dossaji et al., 1977); and techniques used for the control of one snail host may not be effective for another even of the same genus (WHO, 1965). It is essential therefore to undertake the screening of more Nigerian plants to evaluate their molluscicidal activity on L. natalensis.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Laboratory Procedures for Snails

3.1.1. Maintenance of L. natalensis

Egg-laying adult specimens of *L. natalensis* (shell length, 1.5 to 2.0cm) were obtained from Ahmadu Bello University Dam, Zaria. These were maintained in three 10l plastic bath tubs that were two-thirds filled with untreated dam water. Weeds (*Eloidea* species and *Pistia stratiotes*) were floated on the water to provide shelter and oviposition sites for the snails.

Fresh lettuce and *purine dog chew were added as feeds for the snails and silt added with these feeds for mechanical digestion. Decayed lettuce and faecal droppings of the snails were removed daily and the water was changed twice weekly. Air was bubbled into each bath for 3 hours daily by means of two **HYFLO air pumps. Water temperature

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*Pfizer livestock Feeds Limited, Ikeja.

**Medcalf Bros. Ltd., Cranborne Road, Potter Bar Herts, EN6 3JN, England.

temperature varied between 25° - 27°C.

3.1.2. Breeding of L. natalensis

At weekly intervals, the bath tubs were drained and egg masses removed and transferred into a glass aquarium set up as described by Shonekan (1961) for hatching. The aquarium was observed at weekly intervals for emergence of young snails which usually took about two weeks.

L. natalensis were grown in two 45l fibre-glass containing a loosely packed mixture of washed pebbles, gravel and mud-free sand at the bottom to a depth of about 15mm. The aquaria were then filled to about ⅔ capacity with untreated dam water from Ahmadu Bello University Dam, Zaria. Eloidea weed, Pistia stratiotes and young aquatic sedge were introduced as shelter for the young snail and lettuce and a mixture of purine dog chew were added as food. To improve the shell quality of the snails, 0.15gm calcium carbonate ($CaCO_3$) was added per litre of water at weekly intervals as recommended by van Someran (1946). Aeration of the aquaria was done daily for the first five weeks and stopped. Snails averaging 12mm shell length were obtained in 12 weeks

and these were used for the toxicity tests.

3.2. Procedures involving Plants

3.2.1. Collection of Plant Material

Plant material to be screened were collected from Bauchi township, Billiri-Kufai, Dongol, Giricili, Nabordo, Tangláng and Yuga in Bauchi State and Samban, Samaru and Zonkwa in Kaduna State. Information on plant material was obtained by interviewing traditional herbalists and Fulani herdsmen. Information were sought on:

(a) Plants used as soap
(b) Plants used for fishing
(c) Plants used for both (a) and (b) above, and
(d) Plants used in traditional medicine.

Vernacular names and parts of the plants used in traditional usage were documented. Twenty-five specimens of plants were collected with the aid of the local herbalists and preserved in a plant press. These were sent to taxonomists at the Department of Biological Sciences, Ahmadu Bello University Zaria and Bauchi campuses for proper identification.

3.2.2. Preparation of Plant Material for Extraction

As much as possible, only plant parts specified for the traditional usage i.e. bark, flowers, leaves, pods, roots and stem were collected and dried on cement slabs under shade. The dried plant parts were then pounded to powder in a wooden mortar and then stored in labelled containers. Fresh (wet) samples of leaves, roots, and stems were pounded immediately after collection before mixing with methanol or distilled water.

3.3.0. Extraction and Evaluation of Plant Material

Three methods were used for extracting plant material, namely:

a. Evaporated methanolic method

b. Evaporated crude water method, and

c. Unevaporated crude water method.

Extracts recovered from these methods are referred to as methanolic (MEOH), evaporated crude water (ECW) and Unevaporated crude water (UECW) extracts respectively.

3.3.1. Evaporated Methanolic Method

The pounded plant material was mixed with methanol in the ratio of 1:5 weight per volume (W/V) as described by Ibrahim *et al*. (1984) in 1l reagent bottles, conical flasks or measuring cylinders and allowed to stand for 48 hours at ambient temperature. The supernatant was decanted and filtered first through two layers of cheese cloth inserted in a 2.0mm mesh gauze and finally through a 0.42mm mesh gauze. The filtrate was concentrated to dryness in vacuo at 50°C using a rotary evaporator coupled to a thermo-regulator. Extracts obtained were scraped and stored in labelled specimen bottles in a refrigerator.

The pounded fresh (wet) fruits, leaves and root were weighted and mixed at the ratio of 1:5 W/V with methanol, after which they were similarly filtered, evaporated to dryness and stored.

3.3.2. Water Extraction

This was done with slight modification of the method of Ibrahim *et al*. (1984). Pounded plant material was mixed with distilled water at the ratio

of 1:5 W/V and allowed to stand for 48 hours at ambient temperature. The suspension was filtered using the same procedure adapted for the methanolic method and divided into two portions for the evaporated and unevaporated crude water methods.

3.3.3. Evaporated Crude Water Method

The weight of the empty rotary evaporator distillation flask was recorded and a known volume of crude aqueous extract from each sample was introduced and evaporated to dryness at 80^{o}C using the procedure described for the methanolic method. The total yield of evaporated crude extracts was then worked out.

3.3.4. Unevaporated Crude Water Method

The UECW extracts were prepared by negative extrapolation from information obtained through evaporating known volumes of crude aqueous extracts as above. Corresponding volumes of each sample equivalent to 1000ppm were worked out by diluting with appropriate volume of distilled water. Efforts were also made to prepare different concentrations

of each sample immediately for the screening tests as soon as weights of evaporated crude water extracts were known.

3.4. Preparation of Stock Solutions

A gram of each evaporated extract was dissolved in a litre of distilled water to give a concentration of 1000mg/l or 1000ppm which served as the stock solution. For the UECW extracts, concentrations were worked equivalent to 1000ppm/out from information obtained in the evaporated crude water method or by comparing weights of equal volume of extracts with that of distilled water (rough estimate) for the three samples that could not be concentrated. Other concentrations used for the tests were serially diluted from the stock solutions.

The extracts were used immediately for toxicity tests in order to avoid loss of potency.

3.5. Toxicological Procedures

For the toxicity tests, WHO (1965, 1983) standard procedures for preliminary screening of plant for molluscicidal activity were followed.

For each test concentration, four replicates of five snails each were used. Because of non-availability of Niclosamide as recommend by WHO (1981) as a reference molluscicide, $CuSO_4$ was used as the reference molluscicide and, distilled water and untreated dam water used as controls.

Before each test, the snails were washed in distilled water and blotted dry with "Whatman" filter paper. They were then exposed in the test or control medium for a 24-hour period. Observations for peculiar protective behavior of the snails were made at hourly intervals. At the end of each exposure period, snails were washed with distilled water and put in 150ml fresh distilled water for a recovery period of 48 hours as recommended by Lugt (1981). Mortality was confirmed by failure of heart-beat observed by shining light from the bottom of each experimental container using dissecting microscope and failure of snails to retract into their shell when touched with a needle after the prescribed 48-hours recovery period.

3.5 Statistical Analyses

For screening of plant extracts on 12-week old *L. natalensis*, the total number of replicates used for each concentration was four and the total number of snails in all the four replicates of each concentration was 20.

Percentage mortality for each replicate of a concentration is given by:

$$\frac{\text{No. dead}}{\text{No. exposed}} \times 100$$

where No. exposed = 5.

For serial dilutions used in determining lethal concentration values of extracts, the 20 snails exposed in all the four replicates were used.

Percentage mortality is given by:

$$\frac{\text{No. dead}}{\text{No. exposed}} \times 100$$

where No. exposed = 20.

This was done to avoid fractions in the numbers of dead snails since mortality rates have to be in whole numbers for the attachment of the

95% fiducial limits according to the method described by Tallarida and Murray (1981).

For screening of UECW extracts on 2-week old *L. natalensis*, ten snails were used for each of the 10 different concentrations of extracts.

Percentage mortality for each test is given by the same formular as for adult snails.

Mortality data for lethal concentration values for all tests were converted to probit as described by Litchfield and Wilcoxon (1949); and the fiducial limits of the lower and upper LC_{50} at P = 0.50% were obtained as outlined by Tallaride and Murray (1981).

The relationship of Log-concentration-mortality (probit) was plotted for the different extracts.

CHAPTER FOUR

R E S U L T S

4.1 Plants Collected for Screening

Information was obtained on 50 plant species based on their use in soap-making, fishing and traditional medicine. Twenty-five plant species (see plates I - XXV) from 23 families were collected for screening.
Information on the plants is given in Table 1.

4.2. Plant Extracts

4.2.1. MEOH Extracts

Four of the 25 plants extracted in methanol yielded oily gelatinous extracts which separated into an upper light layer and a lower dense layer after four weeks of storage in the refrigerator. These included the fruit of Blighia sapida, the roots of Aristolochia albida, Cissampelos mucronata and Vetiveria nigritana. The solid extract from Cissus quadrangularis after extraction became liquid after about four weeks storage in the refrigerator,

while the solid extracts from the rest of the 20 plants remained in their original solid state even after refrigeration. This suggests that they can remain stable when stored for sometime.

4.2.2. ECW Extracts

Of the 25 plants extracted by use of this method, 20 yielded solid extracts. Two of these, Gmelina arborea and V. nigritana yielded solid extracts which became liquid after about four weeks of refrigeration. Two of the plants Aristolochia albida and C. mucronata yielded oily extracts. B. sapida and Opilia celtidefolia which produced foam and C. quadrangularis which was sticky and mucoid could not be concentrated in vacuo.

Seven of the plant extracts obtained by use of all the three extraction methods foamed when shaken. These were the bark of Balanites aegyptiaca and O. celtidefolia, the fruit of B. sapida and Luffa cylindrica, the root of Securidaca longipedunculata, the pod of Acacia nilotica and the leaves of Vernonia amygdalina.

Extract from Gnidia kraussiana caused strong burning sensation on the mucous membrane of the

eyes and nose while those of the bark of Detarium microcarpum, Kigelia africana, Pseudocedrela kotschyi and the pod of Parkia clappertoniana produced characteristic irritating smell and caused sneezing in humans.

4.3. Testing for Molluscicidal Activity

Details of the tests are given in Table 2. Using WHO (1965) standard, extracts of 18 (72%) of the 25 plants produced by all three extraction methods were molluscicidal as can be seen from Tables 3-5. The ECW method produced extracts that were active in 9 (26%) of the 25 plants, the MEOH method produced extracts that were active in 13 (52%) of the 25 plants while the UECW method produced extracts that were active in 16 (64%) of of the 25 plants. Molluscicidal activity does not appear to be limited to any morphological part of the plants tested nor is it restricted to any plant family.

In five of the 25 plant extracts produced by all three extraction methods were molluscicidal. These include the bark of B. aegyptiaca, Boswellia dalzielii, D. microcarpum, and Ximenia americana

and the pod of P. clappertoniana, while in 10 of them i.e. the bark of K. africana, Pseudocedrela kotschyi and Sclerocarya birrea, the fruit of B. sapida the leaves of Polygonum limnatum, the pod of A. nilotica and the roots of A. albida, G. kraussiana, S. longipedunculata and V. nigritana were molluscicidal with extracts produced by two methods.

In the case of the bark of Nauclea latifolia and O. celtidefolia and the root of Ziziphus abyssinica, only extracts produced by one extraction method were molluscicidal. Extracts of the rest i.e. the bark of Anogeissus leiocarpus, the flower of Gmelina arborea, the fruit of L. cylindrica, the leaves of V. amygdalina, the pod of Posopis africana, the roots of C. mucronata and C. quadrangularis were not molluscicidal when obtained by any of the three extraction methods but all except V. amygdalina appeared molluscicidal at higher concentrations with at least one of the extraction methods (Table 2).

Extracts from N. latifolia, V. amygdalina and V. nigritana precipitated after about an hour of introduction of snails into their solutions, which suggests rapid degradation of these extracts

probably by snail mucous. This phenomenon was not observed with extracts from the remaining 22 plants.

It was observed that most snails dropped to the bottom of test solutions of B. aegyptiaca, B. sapida, L. cylindrica, O. celtidefolia, S. longipedunculata and V. amygdalina but crawled out of extracts of A. nilotica, D. microcarpum, P. clappertoniana, P. limnatum and X. americana.

Poisoning with the extracts caused the adult snails either to retract into the shell (Plate XXVI) or to become swollen and remain extended from the shell opening (Plate XXVII) and expel haemolymph (Plate XXVIII). The former response was seen with extracts of A. nilotica, A. leiocarpus, A. albida, C. quadrangularis, G. aborea, L. cylindrica, N. latifolia, S. birrea, V. amygdalina, V. nigritana, X. americana and Z. abyssinica. The latter response is seen particularly with extracts of the other 13 plants and those of B. aegyptiaca, B. sapida, G. kraussiana, O. celtidefolia and S. longipedunculata as well as $CuSO_4$.

4.4 Determination of Lethal Concentration (LC) values

E tracts from plants that were molluscicidal i.e. producing 100% mortality at 100ppm by each extraction method were diluted serially and more rigorous toxicity tests were evaluated with 12-week old L. natalensis. Detailed mortality data from these tests together with their probit transformation (Litchfield and Wilcoxon, 1949) are shown in Appendices 1 - 3.

Results of statistical analysis of the lethal concentration values for extracts produced by all three extraction methods are shown in Tables 6-8 from which it can be seen that there appear to be significant differences between the lethal concentration values of the different extracts. These differences also exist for the same plant between extracts obtained by different extraction method. In contrast to the reference standard ($CuSO_4$ solution) showed constant LC values.

4.4.1. MEOH Extracts

From the results presented in Appendix 1, it appears that mortality varies with concentration of

MEOH extracts. This is also evident from Table 6 which shows the results of the statistical analysis of lethal concentration values of each extract.

On the basis of LC_{50} fiducial limits (P=0.05%) it appears that extracts of the pod of P. clappertoniana are the most toxic of all those tested. However, their degree of toxicity was not statistically significantly different from that of the back of B. aegyptiaca as can be seen from the overlap of their LC_{50} limits. Similarly, no statistically significant difference in toxicity was noticed between extracts of B. dalzielii, D. microcarpum and G. kraussiana which also appear to be less toxic than P. clappertoniana and B. aegyptiaca. B. sapida though significantly less toxic than the above five plants is more toxic than the remaining seven plants based on LC_{50} as shown in Table 6. There is no statistically significant difference between the toxic effect of S. birrea, S. longipedunculata, P. limnatum and X. americana as shown in the same table which are less toxic than P. clappertoniana to B. sapida. The last three plants, P. kotschyi, Z. abyssinica and A. nilotica are statistically significantly different from each other in their

degree of toxicity which decreased in that order. However, none of the 13 plants is more toxic than $CuSO_4$ solution which has the least LC_{50} value of 0.75 (0.66 - 0.84) ppm.

The slope function effect for the extracts are nearly all the same, varying from 1.06 in A. nilotica to 1.70 in G. kraussiana (Table 6). The implication being that increase in concentration of these extracts may produce about the same mortality rates.

All the X^2 values were not significant for heterogeneity, suggesting that the mortality data of Appendix 1 is not heterogenous. The log-concentration-probit lines plotted from test data of Appendix 1 are shown in Figs 1 - 4. The lines indicate a linear relationship between log-concentration and mortality (probit scale) for each extract.

4.4.2. ECW Extracts

Results for the above extracts are presented in Appendix 2, and the computed lethal concentration values are shown in Table 7 from which it can be seen

that there are marked differences in toxicity of extracts to snails. This is clearly seen from the results of statistical analysis of the lethal concentration values. The LC_{50} values vary from 6.13ppm in B. aegyptiaca to 45.37ppm in K. africana. These values are higher than 0.75ppm for $CuSO_4$ solution thus indicating that these plants are less toxic than $CuSO_4$. Similarly, the 1.07ppm LC_{90} value of $CuSO_4$ indicates higher toxicity than those of the tested extracts which varied from 8.54ppm in B. aegyptiaca to 65.51 ppm in K. africana. B. aegyptiaca and P. clappertoniana produced the most toxic extracts, followed by V. nigritana, D. microcarpum and S. birrea, then X. americana and B. dalzielii in that order.
Extracts of A. albida are significantly less toxic than those of all the above plants, and more toxic than those of K. africana. Extracts of all the nine molluscicidal plants extracted by the ECW method were less toxic than $CuSO_4$ (reference molluscicide).

The slope function of log-concentration and mortality (probit scale) varies from 1.12 in A. albida to 1.86 in D. microcarpum. All the computed X^2 values are not significant for heterogeneity implying that the mortality data are consistent.

Figs 5-7 compare the slopes of the log-concentration-probit lines using the data of Appendix 2. Extracts of A. albida and V. nigritana both produced steeper slopes than both $CuSO_4$ solution and the remaining extracts.

4.4.3. UECW Extracts

Mortality data for snails due to these extracts are shown in Appendix 3, with the computed lethal concentration values presented in Table 8. There are statistically significant differences in LC_{50} values which range from 3.40 ppm in P. clappertoniana to 77.82 ppm in P. kotschyi, all of which are statistically significantly different from that of $CuSO_4$ which was 0.75 ppm.

Based on the LC_{50} limits (P=0.05%) as shown in Table 8, extracts of P. clappertoniana is the most toxic though not significantly different from those of B. aegyptiaca and D. microcarpum because of the overlap in the lower and upper limits. Toxicity of the extracts decreased down the table from B. sapida, P. limnatum, O. celtidefolia and A. nilotica with their LC_{50} limits also overlapping, suggesting that the difference in their respective LC_{50} values

is not statistically significant within the group. X. americana and S. longipedunculata is less toxic than the above eight plants. Others are B. dalzielii, N. latifolia to V. nigritana; G. kraussiana and A. albida; K. africana down to the least toxic of all the extracts, P. kotschyi.

Toxicity of UECW extracts decreased with increase in concentration. It also varied with species being highest in P. clappertoniana, followed by B. aegyptiaca then D. microcarpum in the order as shown in Table 8. However, all these extracts were less toxic than $CuSO_4$ solution, the reference molluscicide as can be seen from LC_{50} values shown in Table 8.

For most of the extracts, the slope function values fell between 1 and 2, except B. aegyptiaca, P. clappertoniana and S. longipedunculata, for which they were greater than 2. As with the MEOH and ECW methods, none of the calculated X^2 values is significant as can be clearly seen from the plot of log-concentration versus mortality (probit scale) shown in Figs 8-11. For P. clappertoniana, B. aegyptiaca and D. microcarpum, whose extracts were more toxic than the other extracts, the plots were

fairly linear and the slope flat while A. albida, K. africana and P. koschyi which were less toxic than the first three plants above, the slopes were steep.

4.5 Comparison of toxic effects of extracts on adult L. natalensis

Toxicities of extracts obtained by the three extraction methods are compared in Table 9 using the LC_{50} limits (P = 0.05%) of all the 18 molluscicidal plants. It can be seen from the table that the toxicities of nearly all UECW extracts were statistically significantly different from those of extracts produced by the other two methods. Nine of the 18 plant extracts produced by the UECW method showed significant increase in toxicity over both the MEOH and the ECW extracts. These include P. clappertoniana, B. aegyptiaca, D. microcarpum, X. americana, B. sapida, P. limnatum, A. nilotica, N. latifolia and O. celtidefolia. The UECW extract of S. longipedunculata had about the same toxicity with that obtained by the MEOH method.

The MEOH extraction method produced the most toxic extracts in B. dalzielii, G. kraussiana,

P. kotschyi and Z. abyssinica. The ECW extracts of A. albida, K. africana, S. birrea and V. nigritana were more toxic than extracts of the same plants produced by the MEOH and ECW methods.

Figs 12-16 show plots of log-concentration against mortality (probit scale) for extracts of five plants which proved to be molluscicidal when produced by all the three extraction methods as shown in Tables 3-5. In all cases the plots were linear and in the case of the MEOH and ECW extracts of B. aegyptiaca the slopes were similar to that of $CuSO_4$ as shown in Fig 13. This implies that equal concentrations of extracts and $CuSO_4$ may give equal mortality. This also apply to the UECW extract of B. dalzielii and the control ($CuSO_4$) as shown in Fig 14, and the MEOH extract of X. americana and $CuSO_4$ (Fig 16). In contrast, the slope for the UECW extracts of B. aegyptiaca (Fig 13), P. clappertoniana (Fig 12) and D. microcarpum (Fig 15) are flatter than that of $CuSO_4$ the standard molluscicide.

4.6 Effect of UECW extracts on 2-week old L. natalensis

Susceptibility of 2-weeks old L. natalensis was evaluated by diluting each extract 10-fold and

exposing 10 snails to each dilution. Details of the tests are presented in Appendix 4 and the results are summarized in Tables 10 and 11 from which it can be seen that five plants i.e. A. nilotica, A. albida, G. kraussiana, M. americana and V. nigritana which were molluscicidal to adult snails at 100 ppm, were not active at the same concentration on young snails. The results further revealed that the other extracts though molluscicidal at 100 ppm on both adult and young snails, differ in their toxicities to young snails as shown by results of the LC values presented in Tables 8 and 11. C. mucronata though not molluscicidal on adult snails at 100ppm (Tables 3 - 5) was toxic to young snails at this concentration (Table 10).

The LC_{50} values range from 0.46 ppm in P. clappertoniana to 61.50 ppm in B. dalzielii and the LC_{90} values from 1.33 ppm also in P. clappertoniana to 166.68 ppm in P. kotschyi. Toxicity of extracts on both adult and young snails differ significantly based on the LC_{50} values and their 95% limits as shown in Table 12. Seven of the samples including $CuSO_4$ solution showed improved toxicity on young snails, requiring almost half of

the LC_{50} values for adult snails. These were P. clappertoniana, D. microcarpum, O. celtidefolia, N. latifolia, K. africana and P. kotschyi. Extracts produced by P. limnatum, B. aegyptiaca, B. sapida, B. dalzielii and S. longipedunculata were apparently less toxic on young snails compared to adults.

The slope function values for most plant extracts are nearly all the same ranging from 1.18 in O. celtidefolia to 1.75 in N. latifolia implying that similar mortalities may be produced with similar doses, except P. clappertoniana, P. kotschyi and $CuSO_4$ which had values of 2.28, 3.32 and 6.27 respectively. As shown in Table 11 X^2 values are not significant which imply that mortality data is homogenous. Plots of log-concentration against mortality (probit) (Figs 17 to 19) are all linear with most of the lines being close to the origin indicating that the extracts are potent.

Table 1: Plants selected for screening based on the local uses as given by local herdsmen and traditional herbalists

Plant Species	Local Names	Part Collected	Month of Collection	Site/ Locality	Local Uses
1. Acacia nilotica DEL.	F-Narehi H-Bagaruwa namiji T-Suirmin	Pod Dry	January	Samaru	Pod used for fishing and together with some additives for treatment of fascioliasis ("Hanta").
2. Anogeissus leiocarpus GUILL & PERR.	H-Marke I-Atara T-Walam Y-Ayin	Bark Dry	August	Nabardo	Bark boiled and used for treatment of worms.
3. Aristolochia albida DUCH.	F-Madachin k'asa H-ga'dakuka T-Domock	Root Dry	September	Tanglang	Dried root pounded and used in treatment of intestinal disorders and worms.
4. Balanites aegyptiaca (LINN.) DEL.	F-Tanni (pl. Tanne) H-Aduwa T-Ankwam'a	Bark Dry	September	Nabardo	Bark and root used as soap and also for fishing.
5. Blighia sapida KOENIG.	F-Feso H-Fisa I-dialects okpu S-Parkuma Y-Ischin	Fruit Wet	January	Samban	Fruits crashed and used as soap.
6. Boswellia dalzielli HUTCH.	F-Andakehi H-Hano or Hanu T-Shemneng	Bark Dry	September	Yuga	Bark used for fishing.

Table 1 (contd.)

Plant Species	Local Names	Part Collected	Month of Collection	Site/ Locality	Local Uses
7. Cissampelos mucronata RICH.	H-Jibjar Kasa I-Agalo abakenwo S-Rindam T-Tonguloro Y-Jen jako	Root Dry	August	Tanglang	Root dried, pounded and mixed with water for intestinal upset and also for treatment of worms.
8. Cissus quadrangularis RICH.	H-Tsattsarar Kura T-Awurkan	Stem Wet	August	Gricilli-Nabordo	Used in treatment of gastro-intestinal complex.
9. Detarium microcapum GUILL & PERR.	H-Taura T-Ankufrang Y-Ogbogbo	Bark Dry	August	Nabordo	Bark thrown into pond for fishing.
10. Gmelina arborea RORB.		Flower Dry	January	Samaru	Based on my observation of the flowers which dropped in pond leading to snail mortality.
11. Gnidia kraussiana (=Lasiosiphon kraussianus) MEINSN.	H - Tururubi F-Sungoje T-"Sha ka Sani"	Root Dry	September	Tanglang	Root pounded and put in pond for fishing and also for treatment of general gestrointestinal disorders
12. Kigelia africana (Lam.) BENTH.	H-Rahaina T-Kutukuta Y-Pandoro or uyan	Bark Dry	September	Nabardo	Bark used for fishing. Also boiled and taken orally for schistosomiasis.

Table 1 (contd.)

Plant Species	Local Names	Part Collected	Month of Collection	Site/ Locality	Local Uses
13. Luffa cylindrica ROEM.	H-Soso I-Alu Olisa T-Soso Y-Erun	Fruit Wet	January	Samaru	Riped and unriped fruits used for washing as soap.
14. Nauclea latifolia SMITH.	H-Tafashiga T-Yesh S-Tess	Bark Dry	September	Nabordo	Back boiled and taken orally for treatment of worms and general intestinal disorders.
15. Opilia celtidifolia (GUILL & PERR) ENDL. EX WALP.	F-Yamoin ngari H-Inuwar gada or Rufar gada T-Lakikume	Bark Dry	August and January	Nabordo and Tanglang	Bark used for washing as soap, also concoction taken orally by humans for treatment of fascioliasis.
16. Parkia clappertoniana (=P. filicoidea) KEAY.	H-Dorawa I-Ogirili-Igala S-Loloh T-Tali Y-Irugba or igba	Pod Dry	May	Dongol	Pod used for fishing.
17. Polygomum limnatum MEISN.	T-Tillo	Leaves Dry	January	Samaru	Leaves crushed and used for fishing.
18. Prosopis africana TAUB.	F-Koli H-K'irya I-Aman kanu ubwa T-Shinji	Pod Dry	October	Nabordo	Pod used for fishing.
19. Pseudocedrela kotschyi HARMS-HOLL.	F-Bodal H-Tonam or Tonas T-Ananan Y-Emigbegbi	Bark Dry	October	Nabordo	Bark used for fishing and also for treatment of gastro-intestinal disorders.

Table 1 (contd.)

Plant Species	Local Names	Part Collected	Month of Collection	Site/ Locality	Local Uses
20. Sclerocarya birrea (A.RICH.) HOCHST.	H-Danya T-Bau S-Poma	Bark Dry	October	Nabordo	Bark used for fishing.
21. Securidaca longipedunculata FRES.	F-Alabi H-Sanya or Uwar magan guna T-Mun S-Yoh Y-Ipeta	Root Wet	September and October	Zonkwa and Samban	Root macerated and used as soap. Also known as "the mother of medicine."
22. Vernonia amygdalina DEL.	F-K'aka'de H-Shiwaka I-Onugbu S-Tyst	Leaves Wet	October	Samaru	Leaves macerated and used as soap.
23. Vetiveria nigritana STAPF.	F-So'dornde H-Jema T-Medar	Root Dry	September	Billiri-Kufai	Root boiled and drenched to cattle for treatment of worms.
24. Ximenia americana LINN.	F-Sab'bulde H-Tsada S-Goh T-Tatum Y-Igo	Back Dry	August	Nabordo	Back used for fishing.
25. Ziziphus abyssinica LAM.	F-Jabi (pl. Jabe) H-Magarya S-Nidyok T-Lai Ledo or Ledo fimana	Root Dry	August	Tanglang	Root boiled and taken orally for treatment of schistosomiasis.

1. Vernacular names used were mainly given by informants and confirmed from Dalziel (1937); "The useful plants of Tropical West Africa" Crown Agents, London.
2. F-Fulani; H-Hausa; I-Igbo; S-Samban; T-Tangale and Y-Yoruba.

Table 2. Comparative preliminary screening of plant extracts on 12-week old Lymnaea natalensis based on WHO (1965, 1983) standards.

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MEOH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UEW extract % Mortality
1. AMPELIDIACEAE	1000	5	0		COULD NOT BE	5	100
Cissus	500	5	0		CONCENTRATED	5	100
quandrangularis	100	5	0		BECAUSE OF ITS	5	45
	50	5	0		MUCOID NATURE	5	25
	10	5	0			5	20
2. ANACARDIACEAE	1000	5	100	5	100	5	20
*Sclerocerya	500	5	100	5	100	5	0
birrea	100	5	100	5	100	5	0
	50	5	100	5	100	5	0
	10	5	0	5	0	5	0
3. ARISTOLOCHIACEAE	1000	5	100	5	100	5	100
*Aristolochia	500	5	100	5	100	5	100
albida	100	5	5	5	100	5	100
	50	5	0	5	100	5	20
	10	5	0	5	0	5	0
4. BIGNONIACEAE	1000	5	100	5	100	5	100
*Kigelia africana	500	5	100	5	100	5	100
	100	5	45	5	100	5	100
	50	5	0	5	55	5	0
	10	5	0	5	0	5	0

Table 2 (contd.)

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MEOH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UECW extract % Mortality
5. CAESALPINIACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Detarium microcarpum	100	5	100	5	100	5	100
	50	5	100	5	100	5	100
	10	5	10	5	30	5	0
6. COMBRETACEAE	1000	5	100	5	100	5	85
	500	5	100	5	100	5	80
Anogeissus leiocarpus	100	5	0	5	20	5	45
	50	5	0	5	0	5	0
	10	5	0	5	0	5	0
7. COMPOSITAE	1000	5	0	5	0	5	75
	500	5	0	5	0	5	65
Vernonia amygdalina	100	5	0	5	0	5	40
	50	5	0	5	0	5	0
	10	5	0	5	0	5	0
8. CUCURBITACEAE	1000	5	0	5	0	5	100
	500	5	0	5	0	5	100
Luffa cylindrica	100	5	0	5	0	5	0
	50	5	0	5	0	5	0
	10	5	0	5	0	5	0
9. BURSERACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Boswellia dalzielii	100	5	100	5	100	5	100
	50	5	100	5	100	5	100
	10	5	35	5	20	5	0

Table 2 (contd.)

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MECH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UECW extract % Mortality
10. GRAMINEAE	1000	5	0	5	100	5	100
	500	5	0	5	100	5	100
*Vetiveria	100	5	0	5	100	5	100
nigritana	50	5	0	5	100	5	55
	10	5	0	5	0	5	0
11. MALIACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Pseudocedrela	100	5	100	5	50	5	100
kotschyi	50	5	10	5	0	5	0
	10	5	0	5	0	5	0
12. MENISPERMACEAE	1000	5	40	5	40	5	100
	500	5	15	5	15	5	100
Cissampelos	100	5	0	5	0	5	40
mucronata	50	5	0	5	0	5	0
	10	5	0	5	0	5	0
13. MIMOSACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
(i) *Acacia	100	5	100	5	25	5	100
nilotica	50	5	0	5	0	5	100
	10	5	0	5	0	5	100
(ii) Parkia	1000	5	100	5	100	5	100
clappertoniana	500	5	100	5	100	5	100
	100	5	100	5	100	5	100
	50	5	100	5	100	5	100
	10	5	90	5	95	5	100

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MEOH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UECW extract % Mortality
(iii) *Prosopis africana*	1000	5	100	5	0	5	100
	500	5	100	5	0	5	55
	100	5	5	5	0	5	0
	50	5	0	5	0	5	0
	10	5	0	5	0	5	0
14. OLACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Ximenia americana	100	5	100	5	100	5	100
	50	5	100	5	100	5	100
	10	5	0	5	0	5	0
15. OPILIACEAE	1000	5	100		COULD NOT BE	5	100
	500	5	100		CONCENTRATED	5	100
*Opilia celtidefolia	100	5	25		BECAUSE OF ITS	5	100
	50	5	5		FOAMY NATURE.	5	100
	10	5	0			5	25
16. POLYGALACEAE	1000	5	100	5	15	5	100
	500	5	100	5	0	5	100
*Securidaca longipedunculata	100	5	100	5	0	5	100
	50	5	0	5	0	5	80
	10	5	5	5	0	5	25
17. POLYGONACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Polygonum limnatum	100	5	100	5	0	5	100
	50	5	100	5	0	5	100
	10	5	0	5	0	5	0

Table 2 (contd.)

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MEOH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UECW extract % Mortality
18. RHAMNACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Ziziphus abyssinica	100	5	100	5	20	5	80
	50	5	0	5	25	5	0
	10	5	0	5	0	5	0
19. RUBIACEAE	1000	5	100	5	100	5	100
	500	5	100	5	35	5	100
*Nauclea latifolia	100	5	0	5	5	5	100
	50	5	0	5	0	5	55
	10	5	0	5	0	5	0
20. SAPINDACEAE	1000	5	100	COULD NOT BE		5	100
	500	5	100	CONCENTRATED		5	100
*Blighia sapida	100	5	100	BECAUSE OF ITS		5	100
	50	5	100	FOAMY NATURE.		5	100
	10	5	0			5	40
21. THYMELACACEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Gnidia kraussiana (=Lasiosiphon kraussianus)	100	5	100	5	0	5	100
	50	5	100	5	0	5	60
	10	5	30	5	0	5	0
22. VERBENACEAE	1000	5	15	5	100	5	100
	500	5	0	5	100	5	100
Gmelina arborea	100	5	0	5	0	5	0
	50	5	0	5	0	5	0
	10	5	0	5	0	5	0

Table 2 (contd.)

Plant Family and Species	Conc. in (PPM)	Ave. No. Exposed	MEOH extract % Mortality	Ave. No. Exposed	ECW extract % Mortality	Ave. No. Exposed	UECW extract % Mortality
23. ZYGOPHYLLZCEAE	1000	5	100	5	100	5	100
	500	5	100	5	100	5	100
*Balanites aegyptiaca	100	5	100	5	100	5	100
	50	5	100	5	100	5	100
	10	5	100	5	100	5	100
$CuSO_4$	10	5	100				
	8	5	100				
	6	5	100				
	4	5	100				
	2	5	100				
Untreated dam water	-	5	0				
Distilled water	-	5	0				

*Plants that have passed WHO (1965, 1983) standards.

Table 3. Summary of screening of methanolic (MEOH) extracts on 12-week old Lymnaea natalensis

Plant Species	Part tested	Ave. No. Exposed	% Mortality at 100 PPM	C o m m e n t
1.*A. nilotica	Pod	5	100	Molluscicidal
2. A. leiocarpus	Bark	5	0	Non-Molluscicidal
3. A. albida	Root	5	5	Non-Molluscicidal
4. *B. aegyptiaca	Bark	5	100	Molluscicidal
5. *B. sapida	Fruit	5	100	Molluscicidal
6. *B. dalzielii	Bark	5	100	Molluscicidal
7. C. mucronata	Root	5	0	Molluscicidal
8. C. quadrangularis	Stem	5	0	Non-Molluscicidal
9. *D. microcarpum	Bark	5	100	Molluscicidal
10. G. arborea	Flower	5	0	Non-Molluscicidal
11. *G. kraussiana	Root	5	100	Molluscicidal
12. K. africana	Bark	5	45	Non-Molluscicidal
13. L. cylindrica	Fruit	5	0	Non-Molluscicidal
14. N. latifolia	Bark	5	0	Non-Molluscicidal
15. O. celtidefolia	Bark	5	25	Non-Molluscicidal
16. *P. clappertoniana	Pod	5	100	Molluscicidal
17. *P. limnatum	Leaves	5	100	Molluscicidal
18. P. africana	Pod	5	5	Non-Molluscicidal
19. *P. kotschyi	Bark	5	100	Molluscicidal
20. *S. birrea	Bark	5	100	Molluscicidal
21. *S. longipedunculata	Root	5	100	Molluscicidal
22. V. amygdalina	Leaves	5	0	Non-Molluscicidal
23. V. nigritana	Root	5	0	Non-Molluscicidal
24. *X. americana	Bark	5	100	Molluscicidal
25. *Z. abyssinica	Root	5	100	Molluscicidal
$CuSO_4$ (reference molluscicide)		5	100	Molluscicidal
Untreated Dam Water (Control)		5	0	Non-Molluscicidal
Distilled Water (Control)		5	0	Non-Molluscicidal

*A plant is molluscicidal when it had 100% mortality at 100 ppm, based on WHO (1965) standard.

Table 5. Summary of screening of unevaporated crude water (UECW) extracts on 12-week old Lymnaea natalensis.

Plant Species	Part tested	Ave. No. Exposed	% Mortality at 100 ppm	Comments
1. *A. nilotica	Pod	5	100	Molluscicidal
2. A. leiocarpus	Bark	5	45	Non-Molluscicidal
3. *A. albida	Root	5	100	Molluscicidal
4. *B. aegyptiaca	Bark	5	100	Molluscicidal
5. *B. sapida	Fruit	5	100	Molluscicidal
6. *E. dalzielii	Bark	5	100	Molluscicidal
7. C. mucronata	Root	5	40	Non-Molluscicidal
8. C. quadrangularis	Stem	5	45	Non-Molluscicidal
9. *D. microcarpum	Bark	5	100	Molluscicidal
10. G. arborea	Flower	5	0	Non-Molluscicidal
11. *G. kraussiana	Root	5	100	Molluscicidal
12. *K. africana	Bark	5	100	Molluscicidal
13. L. cylindrica	Fruit	5	0	Non-Molluscicidal
14. *N. latifolia	Bark	5	100	Molluscicidal
15. *O. celtidefolia	Bark	5	100	Molluscicidal
16. *P. clappertoniana	Pod	5	100	Molluscicidal
17. *P. limnatum	Leaves	5	100	Molluscicidal
18. P. africana	Pod	5	0	Non-Molluscicidal
19. *P. kotschyi	Bark	5	100	Molluscicidal
20. S. birrea	Bark	5	0	Non-Molluscicidal
21. *S. longipedunculata	Root	5	100	Molluscicidal
22. V. amygdalina	Leaves	5	40	Non-Molluscicidal
23. *V. nigritana	Root	5	100	Molluscicidal
24. *X. americana	Bark	5	100	Molluscicidal
25. Z. abyssinica	Root	5	80	Non-Molluscicidal
$CuSO_4$ (reference molluscicide)		5	100	Molluscicidal
Untreated Dam Water (Control)		5	0	Non-Molluscicidal
Distilled Water (Control)		5	0	Non-Molluscicidal

*A plant is molluscicidal when it had 100% mortality at 100 ppm, based on WHO (1965) standard.

Table 6. Statistical analysis of lethal concentrations of methanolic (MEOH) extracts on 12-week old Lymnaea natalensis .

Serial No.	Plant Species N = 5	LC_{10} (PPM)	LC_{16} (PPM)	LC_{50} (PPM)	LC_{84} (PPM)	LC_{90} (PPM)	LC_{95} (PPM)	Slope function (S)	X^2	Lower and Upper values of LC_{50} at 95% probability level (PPM
1.	Parkia clappertoniana	4.05	4.49	6.40	9.12	10.10	11.50	1.43	3.10 NS	5.64 - 7.26
2.	Balanites aegyptiaca	5.15	5.56	7.26	9.48	10.24	11.29	1.31	2.38 NS	6.46 - 8.17
3.	Boswellia dalzielii	6.92	7.72	11.23	16.33	18.20	20.87	1.46	1.63 NS	9.81 - 12.84
4.	Detarium microcarpum	9.55	9.94	11.42	13.11	13.65	14.36	1.15	2.66 NS	10.87 - 12.00
5.	Gnidia kraussiana	6.13	7.14	12.14	20.64	24.06	29.21	1.70	3.10 NS	10.48 - 14.07
6.	Blighia sapida	9.82	11.13	17.21	26.61	30.18	35.39	1.55	1.94 NS	14.72 - 20.12
7.	Sclerocarya birrea	15.48	16.89	22.88	30.98	33.82	37.78	1.35	2.51 NS	21.03 - 24.89
8.	Securidaca longipedunculata	14.01	15.54	22.23	31.81	35.28	40.21	1.43	4.90 NS	19.56 - 25.28
9.	Polygonum limnatum	16.26	17.73	23.92	32.28	35.20	39.26	1.35	4.95 NS	21.48 - 26.63
10.	Ximenia americana	19.49	20.70	25.50	31.42	33.37	36.01	1.23	0.75 NS	23.27 - 27.95
11.	Pseudocedrela kotschyi	40.01	42.35	51.56	62.77	66.44	71.39	1.22	1.34 NS	48.50 - 54.80
12.	Ziziphus abyssinica	65.11	67.25	75.21	84.11	86.87	90.49	1.12	3.31 NS	72.25 - 78.28
13.	Acacia nilotica	74.87	76.05	80.28	84.74	86.08	87.80	1.0[illegible]	2.93 NS	78.74 - 81.85
14.	$CuSO_4$ (ref. standard)	0.52	0.57	0.75	0.98	1.07	1.08	1.32	2.63 NS	0.66 - 0.84

NS - Not significant ($P<0.05\%$)

N = Average number of snails exposed per concentration.

Table 7. Statistical analysis of lethal concentrations of evaporated crude water (ECW) extracts on 12 week- old Lymnaea natalensis

Serial No.	Plant Species N = 5	LC_{10} (PPM)	LC_{16} (PPM)	LC_{50} (PPM)	LC_{84} (PPM)	LC_{90} (PPM)	LC_{95} (PPM	Slope Function (S)	X^2	Lower and Upper Values of LC_{50} at 95% probability level (PPM
1.	Balanites aegyptiaca	4.40	4.74	6.13	7.93	8.54	9.38	1.29	4.91 NS	5.48 - 6.86
2.	Parkia clappertoniana	4.38	4.90	7.21	10.61	11.87	13.67	1.47	4.16 NS	6.47 - 8.03
3.	Vetiveria nigritana	12.35	12.89	14.98	17.40	18.17	19.19	1.16	2.53 NS	14.20 - 15.81
4.	Detarium microcarpum	6.79	8.13	15.11	28.11	33.62	42.18	1.86	3.77 NS	12.47 - 18.33
5.	Sclerocarya birrea	11.12	11.97	15.60	20.04	21.59	23.72	1.29	1.54 NS	14.30 - 16.78
6.	Ximenia americana	12.75	14.34	21.49	32.21	36.21	41.98	1.50	2.30 NS	18.95 - 24.37
7.	Boswellia dalzielii	12.12	13.94	22.64	36.78	42.31	50.51	1.62	1.86 NS	19.79 - 25.91
8.	Aristolochia albida	31.26	32.32	36.29	40.74	42.13	43.95	1.12	1.12 NS	35.01 - 37.62
9.	Kigelia africana	31.43	34.12	45.37	60.33	65.51	72.69	1.33	1.95 NS	41.92 - 49.11
10.	$CuSO_4$ (reference molluscicide)	0.52	0.57	0.75	0.98	1.07	1.18	1.32	2.63 NS	0.66 - 0.84

NS: Not significant ($P<0.05\%$)

N = Average number of snails exposed per concentration.

Table 8. Statistical analysis of lethal concentrations of unevaporated crude water (UECW) extracts on 12-week old Lymnaea natalensis

Serial No.	Plant Species N = 5	LC_{10} (PPM)	LC_{16} (PPM)	LC_{50} (PPM)	LC_{84} (PPM)	LC_{90} (PPM)	LC_{95} (PPM)	Slope Function (S)	X^2		Lower and Upper Values of LC_{50} at 95% probability level (PPM)
1.	Parkia clappertoniana	0.91	1.22	3.40	9.50	12.78	18.60	2.79	3.11	NS	2.35 - 4.91
2.	Balanites aegyptiaca	1.15	1.48	3.53	8.42	10.81	14.85	2.38	7.14	NS	2.70 - 4.63
3.	Detarium microcarpum	1.91	2.31	4.50	8.75	10.60	13.52	1.95	7.88	NS	3.66 - 5.53
4.	Blighia sapida	6.17	7.11	11.60	18.93	21.81	26.08	1.63	2.69	NS	9.73 - 13.83
5.	Polyganum limnatum	6.84	7.91	13.09	21.66	25.05	30.10	1.65	1.04	NS	10.93 - 15.68
6.	Opilia celtidefolia	8.75	9.98	15.74	24.81	28.29	33.41	1.58	2.78	NS	13.37 - 18.53
7.	Acacia nilotica	8.42	9.74	16.14	26.75	30.95	37.23	1.66	2.03	NS	13.80 - 18.87
8.	Ximenia americana	13.49	14.22	17.06	20.47	21.57	23.05	1.20	0.45	NS	15.98 - 18.21
9.	Securidaca longipedunculata	7.64	9.59	21.11	46.44	58.32	77.79	2.20	3.22	NS	16.95 - 26.27
10.	Boswellia dalzielli	23.25	25.01	32.21	41.48	44.62	48.94	1.29	0.80	NS	29.77 - 34.83
11.	Nauclea latifolia	28.17	30.74	41.60	56.28	61.42	68.59	1.35	4.46	NS	37.87 - 45.69
12.	Vetiveria nigritana	34.68	37.24	47.69	61.05	65.57	71.76	1.28	4.71	NS	44.52 - 51.07
13.	Gnidia kraussiana	36.69	39.26	49.66	62.80	67.21	73.23	1.27	2.96	NS	46.52 - 53.00
14.	Aristolochia albida	46.54	48.82	57.61	67.98	71.31	75.75	1.18	1.51	NS	54.29 - 61.12
15.	Kigelia africana	54.12	57.02	68.30	81.81	86.18	92.05	1.20	0.38	NS	64.02 - 72.86
16.	Pseudocedrela kotschyi	71.92	73.20	77.82	82.74	84.21	86.12	1.06	2.99	NS	76.14 - 79.55
17.	$CuSO_4$ (reference molluscicide)	0.52	0.57	0.75	0.98	1.07	1.18	1.32	2.63	NS	0.66 - 0.84

NS = Not significant ($P<0.05\%$)

N = Average number of snails exposed per concentration.

Table 9. Comparative toxicities of extracts obtained by the three extraction methods on 12 weeks old Lymnaea natalensis based on the lower and upper limits (P<0.05%) of the computed LC_{50}

Plant Species	Extract	LC_{50} and limits (ppm)	Comments
1. Parkia clappertoniana	MEOH	6.40 (5.64- 7.26)	UECW extract significantly more toxic than the MEOH and ECW extracts.
	ECW	6.13 (6.47- 8.03)	
	*UECW	3.40 (2.35- 4.91)	
2. Boswellia dalzielii	*MEOH	11.23 (9.81-12.84)	The toxic effect of all the three extracts significantly differ from each other. MEOH extract being the most toxic
	ECW	22.64(19.79-25.91)	
	UECW	32.21(29.77-34.84)	
3. Balanites aegyptiaca	MEOH	7.26 (6.46- 8.17)	UECW extract significantly more toxic than the MEOH and ECW extracts.
	ECW	6.13 (5.48- 6.86)	
	*UECW	3.53 (2.70- 4.63)	
4. Detarium microcarpum	MEOH	11.42(10.87-11.99)	The toxic effect of all the three extracts differ from each other. The UECW extract being the most toxic.
	ECW	15.11(12.47-18.33)	
	*UECW	4.50 (3.66- 5.53)	
5. Ximenia americana	MEOH	25.50(23.27-27.95)	The toxic effect of all the three extracts differ from each other. ECW extract most toxic than MEOH and UECW extracts.
	ECW	21.49(18.95-24.37)	
	*UECW	17.06(15.98-18.21)	
6. Gnidia kraussiana	*MEOH	12.14(10.48-14.07)	The toxic effect of both extracts differ from each other.
	UECW	49.66(46.52-53.00)	

Table 9 (contd.)

Plant Species	Extract	LC_{50} and limits (ppm)	Comments
7. Blighia sapida	MEOH *UECW	17.21(14.72-20.12) 11.60 (9.73-13.83)	Toxic effect of UECW extract differ significantly from MEOH.
8. Securidaca longipedunculata	MEOH UECW	22.23(19.56-25.28) 21.11(16.95-26.27)	Both extracts had about the same toxicity.
9. Sclerocarya birrea	MEOH *ECW	22.88(21.03-24.89) 15.49(14.30-16.78)	Toxicity of both extracts differ significantly from each other.
10. Polygonum limnatum	MEOH *UECW	23.92(21.48-26.63) 13.09(10.93-15.68)	The toxic effect of both extracts significantly differ from each other.
11. Pseudocedrela kotschyi	*MEOH UECW	51.56(48.50-54.80) 77.82(76.14-79.55)	MEOH extract significantly more toxic than the UECW extract.
12. Acacia nilotica	MEOH *UECW	80.28(78.74-81.85) 16.14(13.80-18.89)	The UECW extract is significantly more toxic than the MEOH extract.
13. Vetiveria nigritana	*ECW UECW	14.98(14.20-15.81) 47.69(44.52-51.07)	ECW extract significantly more toxic than the UECW extract.
14 Aristolochia albida	*ECW UECW	36.29(35.01-37.62) 57.61(54.29-61.13)	The ECW extract significantly more toxic than the UECW extract.

Table 9 (contd.)

Plant Species	Extract	LC_{50} and limits (ppm)	Comments
15. Kigelia africana	*ECW UECW	45.37(41.92-49.11) 68.30(64.02-72.86)	The ECW extract significantly more toxic than the UECW extract.
16. Ziziphus abyssinica	**MEOH	75.21(72.25-78.28)	The only extract that had the most toxic effect on adult snails.
17. Opilia celtidefolia	**UECW	15.74(13.37-18.53)	The only extract that had the most significantly toxic effect on adult snails.
18. Nauclea latifolia	**UECW	41.60(37.87-45.69)	The only extract that had the most significantly toxic effect on adult snails.
19. $CuSO_4$	Reference molluscicide	0.75 (0.66- 0.84)	$CuSO_4$ is significantly more toxic than either extract.

*LC_{50} for extracts of these plants are significantly different to values of other extracts for the same plant. Their LC50 limits do not overlap.

**Extract producing the most significantly toxic effect relative to the other extracts of the same plant.

MEOH - methanolic extract; ECW - Evaporated crude water extract; UECW - Unevaporated crude water extract.

Table 10. Summary of effect of 100ppm unevaporated crude water (UECW) extracts on 2-week old Lymnaea natalensis

Plant Species	Part tested	Ave. No. Exposed	% Mortality at 100 PPM	C o m m e n t s
1. A. nilotica	Pod (dry)	5	0	Non-Molluscicidal
2. A. albida	Root (dry)	5	10	Non-Molluscicidal
3.*B. aegyptiaca	Bark (dry)	5	100	Molluscicidal
4. *B. sapida	Fruits (wet)	5	100	Molluscicidal
5. *B. dalzielii	Root (dry)	5	100	Molluscicidal
6. *C. mucronata	Root (dry)	5	100	Molluscicidal
7. *D. microcarpum	Bark (dry)	5	100	Molluscicidal
8. G. kraussiana	Root (Dry)	5	0	Non-Molluscicidal
9. *K. africana	Bark (Dry)	5	100	Molluscicidal
10. *O. celtidefolia	Bark (dry)	5	100	Molluscicidal
11. *P. clappertoniana	Pod (dry)	5	100	Molluscicidal
12. *P. limnatum	Leaves (dry)	5	100	Molluscicidal
13. *P. kotschyi	Bark (dry)	5	100	Molluscicidal
14. *N. latifolia	Bark (dry)	5	100	Molluscicidal
15. *S. longipedunculata	Root (wet)	5	100	Molluscicidal
16. X. americana	Bark (Dry)	5	0	Non-Molluscicidal
17. V. nigritana	Root (dry)	5	10	Non-Molluscicidal
18. $CuSO_4$ (2ppm)		5	100	Molluscicidal
19. Untreated Dam Water		5	0	Non-Molluscicidal
20. Distilled water		5	0	Non-Molluscicidal

1. Extracts were molluscicidal when 100% mortality were recorded at 100ppm based on WHO (1965) standard.
2. Tests were carried out only on UECW extracts that were active on 12-week old L. natalensis except Cissampelos mucronata.

Table 11. Statistical analysis of expected effective concentrations of unevaporated crude water (UECW) extracts on 2-week old L. natalensis.

Serial No.	Plant Species N = 5	LC_{10} (PPM)	LC_{16} (PPM)	LC_{50} (PPM)	LC_{84} (PPM)	LC_{90} (PPM)	LC_{95} (PPM)	Scope Function (s)	X^2	Lower and Upper Values of LC_{50} at 95% probability level (PPM)
1.	Parkia clappertoniana	0.16	0.20	0.46	1.05	1.33	1.80	2.28	2.33 NS	0.32 - 0.66
2.	Detarium microcarpum	1.54	1.73	2.60	3.91	4.40	5.10	1.50	1.45 NS	2.02 - 3.35
3.	Opilia celtidefolia	5.77	6.06	7.17	8.49	8.92	9.42	1.18	1.44 NS	6.46 - 7.96
4.	Balanites aegyptiaca	5.73	6.09	7.51	9.25	9.82	10.60	1.23	1.40 NS	6.75 - 8.34
5.	Kigelia africana	3.17	6.03	10.33	17.70	20.67	25.16	1.71	1.96 NS	6.45 - 16.56
6.	Nauclea latifolia	5.64	6.62	11.60	21.17	23.69	29.04	1.75	1.69 NS	8.19 - 16.32
7.	Pseudocedrela kotschyi	7.58	10.72	35.54	117.91	166.68	258.29	3.32	4.85 NS	25.50 - 49.55
8.	Securidaca longipedunculata	23.92	26.42	37.26	52.55	58.04	65.80	1.41	3.03 NS	31.31 - 44.34
9.	Cissampelos mucrinata	17.73	21.01	37.82	68.09	80.68	100.01	1.60	3.52 NS	28.10 - 50.92
10.	Polygonum limnatum	26.97	30.86	47.19	78.41	89.71	106.37	1.59	2.37 NS	38.86 - 62.27
11.	Blighia sapida	42.61	45.17	55.30	67.69	71.77	77.27	1.22	3.97 NS	48.78 - 62.68
12.	Boswellia dalzielii	48.26	50.95	61.50	74.22	78.36	83.93	1.21	2.67 NS	52.16 - 72.51
	$CuSO_4$ (ref. molluscicide)	0.00	0.00	0.03	0.17	0.29	0.57	6.27	4.05 NS	0.01 - 0.14

NS = Not significant ($P<0.05\%$)

N = Average number of snails exposed per concentration.

Table 12. Comparative toxicities of unevaborated crude water (UECW) extracts on 12-week and 2-week old Lymnaea natalensis

Plant Species	LC_{50} of 12 weeks old snails and limits (PPM)	LC_{50} of 2 weeks old snails and limits (PPM)
1. Parkia clappertoniana	3.40 (2.35 - 4.91)[2]	0.46 (0.32 - 0.66)[1]
2. Balanites aegyptiaca	3.53 (2.70 - 4.63)[2]	7.51 (6.75 - 8.34)[1]
3. Detarium microcarpum	4.50 (3.66 - 5.53)[2]	1.73 (2.02 - 3.34)[1]
4. Blighia sapida	11.60 (9.73 -13.83)[2]	55.30(48.78 -62.68)
5. Polygonum limnatum	13.09(10.93 -15.68)[2]	47.19(38.86 -62.27)[1]
6. Opilia celtidefolia	15.74(13.37 -18.53)	7.17 (6.46 - 7.96)[1]
7. Acacia nilotica	16.14(13.80 -18.89)	Not toxic to young snails
8. Ximenia americana	17.06(15.98 -18.21)[2]	Not toxic to young snails
9. Securidacca longipedunculata	21.11(16.95 -26.27)[2]	37.26(31.31 -44.34)
10. Boswellia dalzielii	32.21(29.77 -34.84)[2]	61.50(52.16 -72.51)[1]
11. Nauclea latifolia	41.60(37.87 -45.69)	11.56 (8.19 -16.32)[1]
12. Vetiveria nigritana	47.68(44.52 -51.07)	Not toxic to young snails
13. Gnidia kraussiana	49.66(46.52 -53.00)	Not toxic to young snails
14. Aristolochia albida	57.60(54.29 -61.13)	Not toxic to young snails
15. Kigelia africana	68.30(64.02 -72.86)	10.33 (6.45 -16.56)[1]
16. Pseudocedrela kotschyi	77.82(76.14 -79.55)	35.54(25.50 -49.55)[1]
17. Cissampelos mucronata	Not toxic to adult snails	37.82(28.10 -50.92)
$CuSO_4$ (ref. molluscicde)	0.75 (0.66 - 0.84)	0.03 (0.01 - 0.14)

[1]Samples that showed improved toxicity of extracts to young snails over adult snails.

[2]Samples that showed improved toxicity of extracts to adult snails over young snails.

Lower and Upper LC_{50} limits in parenthesis.



Plate III. Aristolochia albida DUCH.: Climber; stem with leaves, flower and fruits.



Plate II: Anogeissus leiocarpus GUILL & PERR.:
Old branch with leaves and fruit.



Plate I. Acacia nilotica DEL.: Main branch with leaves and fruits.



Plate IV. Balanites aegyptiaca (LINN.) DEL.:
Old branch with leaves and thorns.



Plate V. Blighia sapida KOENIG.: Old branch with fruits and leaves.



Plate VI. Boswellia dalzielii HUTCH.: Young branch with leaves.



Plate VII. Cissampelos mucronata RICH.: Stem with leaves and bracts.



Plate VIII. Cissus quadrangularis RICH.: Squared-stem, tendrils and leaves.



Plate IX. Detarium microcarpum GUILL & PERR.:
Young branch with old and new leaves.



Plate X. Gmelina arborea ROXB.: Young stem and bunch of fruits and flower.



Plate XI. Gnidia kraussiana MEINSN.· Shoot with linear leaves.



Plate XII. Kigelia africana (LAM.) BENTH.:
Young stem with leaves.



Plate XIII. Luffa cylindrica ROEM.: Stem with tendrils, leaves and matured light brown fruit.



Plate XIV. Nauclea latifolia SMITH.: Old branch with fruit and leaves.

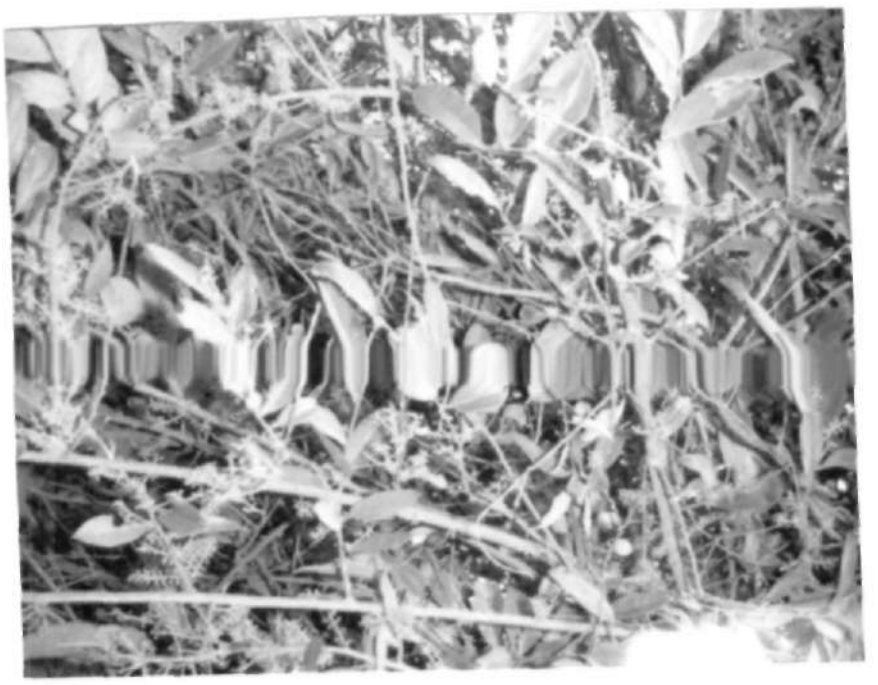


Plate XV. Opilia celtidefolia (GUILL. & PERR) ENDL. EX WALP.: Old stem with fruits, leaves and flowers.



Plate XVI. *Parkia clappertoniana* KEAY.: Young branch with fruits and leaves.



Plate XVII. Polygonum limnatum MEISN.: Stem with leaves, fruits and flowers.



Plate XVIII. Prosopis africana TAUB.: Young branch with flowers, leaves and fruits.



Plate XIX. Pseudocedrela kotschyi HARMS-HOLL.:
Young stem with old and new leaves.



Plate XX. Sclerocarya birrea (A. RICH) HOCHST.:
Old stem with leaves and fruits.



Plate XXI. Securidaca longipedunculata FRESS.:
Old stem and leaves.



Plate XXII. Vernonia amygdalina DEL.: Young stem, leaves and flower.



Plate XXIII. Vetiveria nigritana STAPF.: Stem, leaves and flowers.



Plate XXIV. Ximenia americana LINN.: Old stem, leaves and sharp thorns.



Plate XXV. Ziziphus abyssinica LAM.: Old stem with leaves and curved thorns.



Plate XXVI. Dead Lymnaea natalensis retracted into the shell.

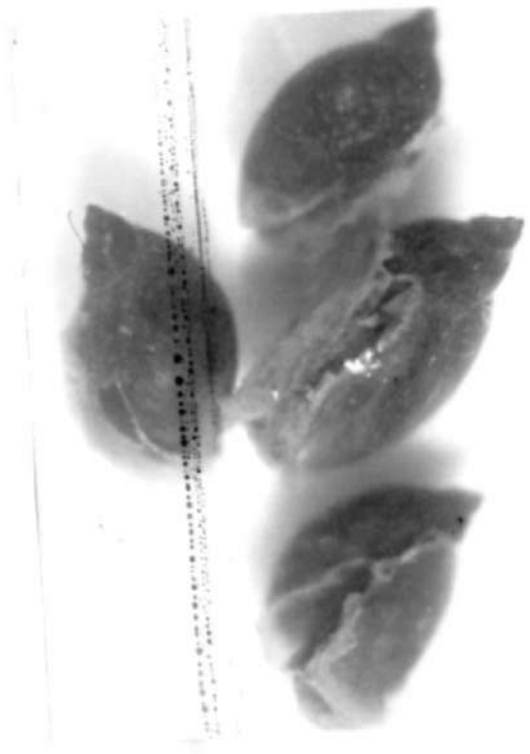


Plate XXVII. Dead Lymnaea natalensis swollen and extended out of shell opening.



Plate XXVIII. Dead Lymnaea natalensis expelling haemolymph.

A. n. = Acacia nilotica
B. a. = Balanites aegyptiaca
B. d. = Boswellia dalzielii
D. m. = Detarium microcarpum
P. c. = Parkia clappertoniana

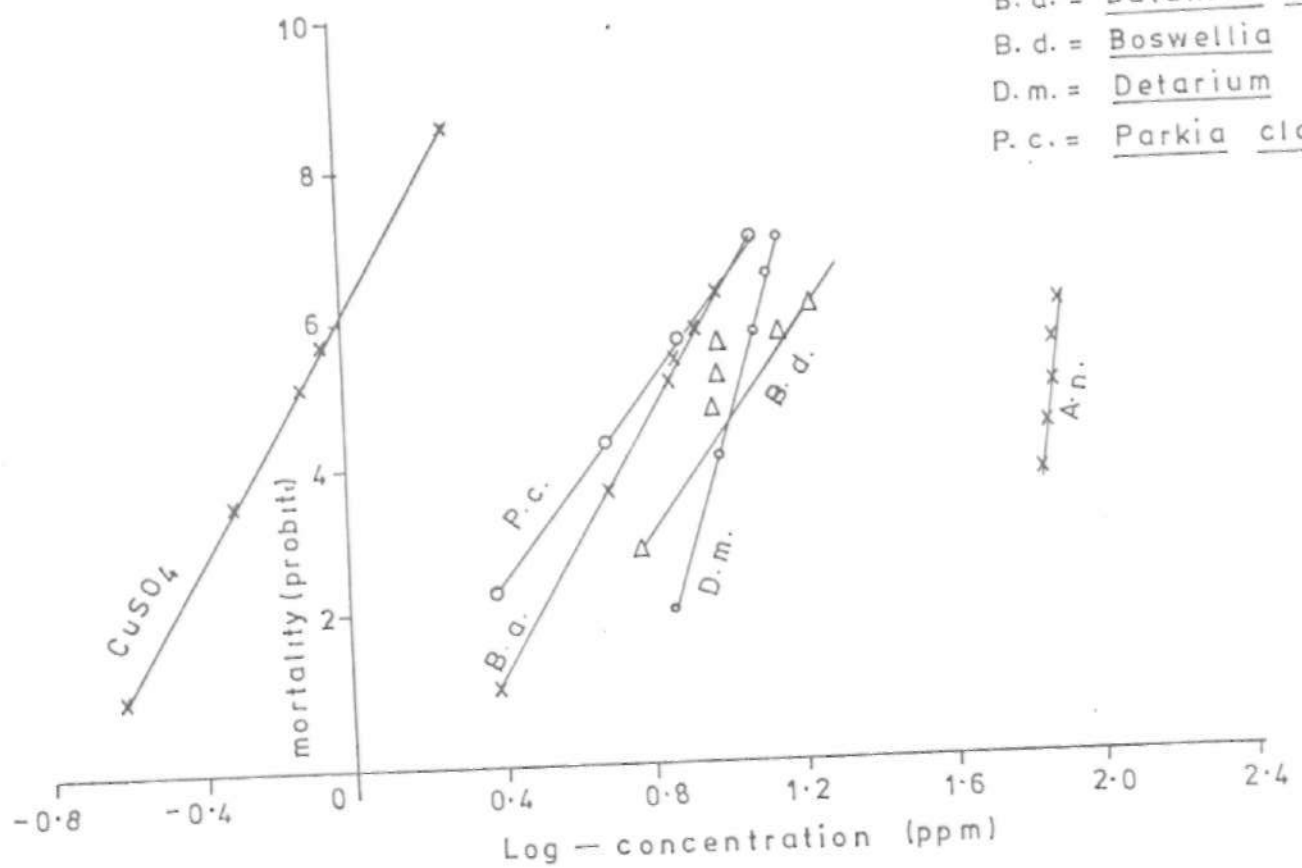


Fig. 1 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to MEOH extracts for 24 hours

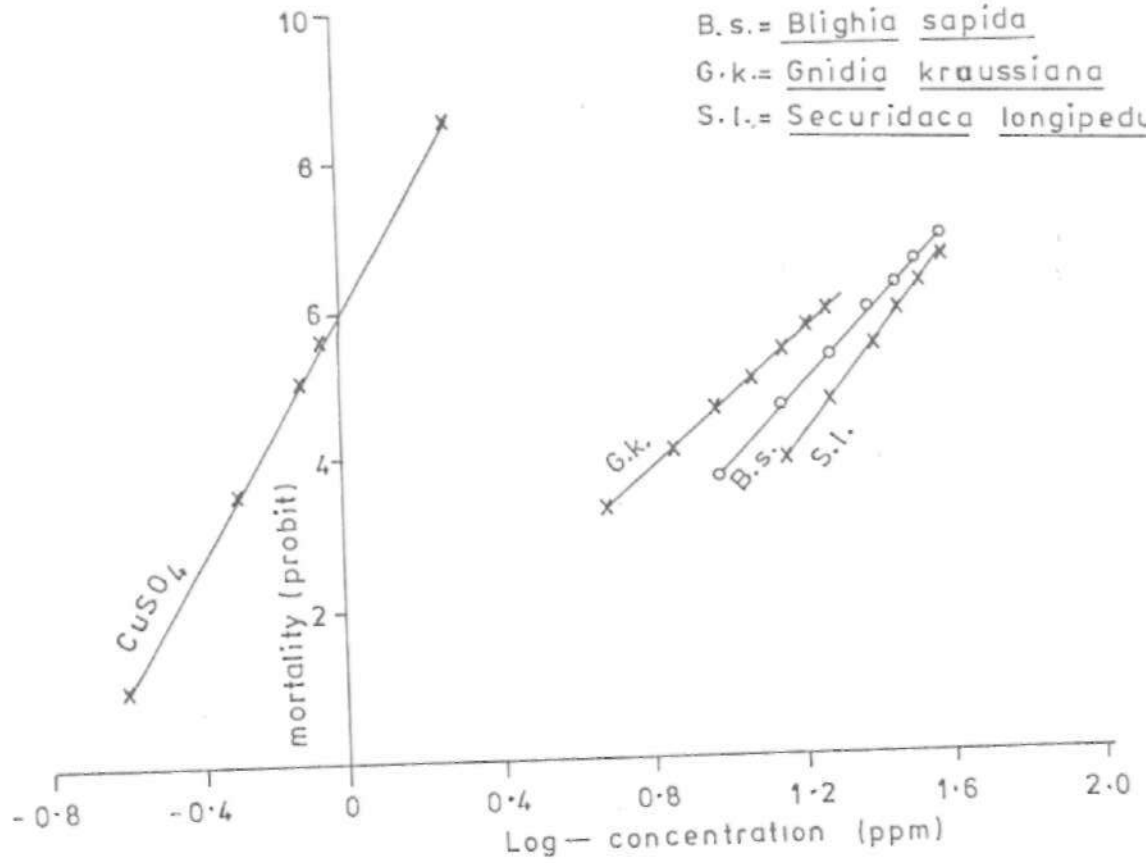
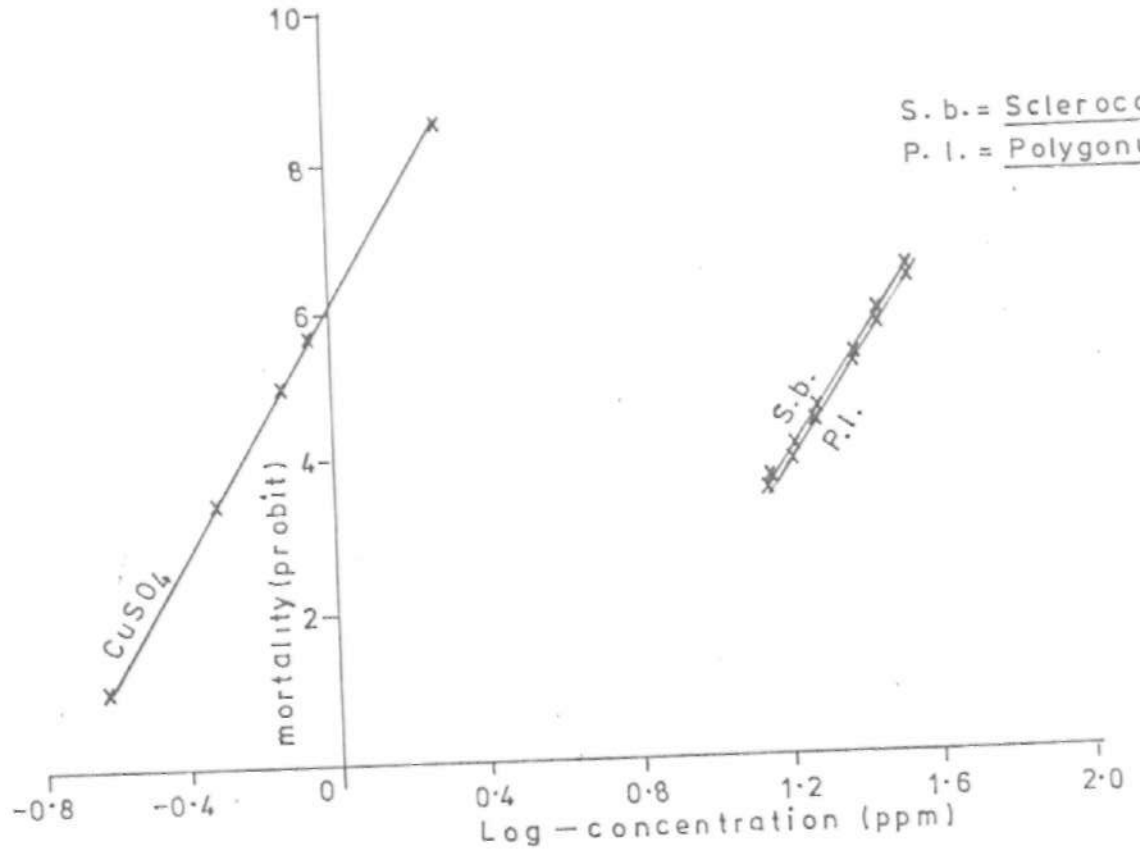


Fig. 2 Relationship of Log—concentration to mortality [probit scale] for adult L. natalensis exposed to MEOH extracts for 24 hours



S. b. = Sclerocarya birrea
P. l. = Polygonum limnatum

Fig. 3 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to MEOH extracts for 24 hours

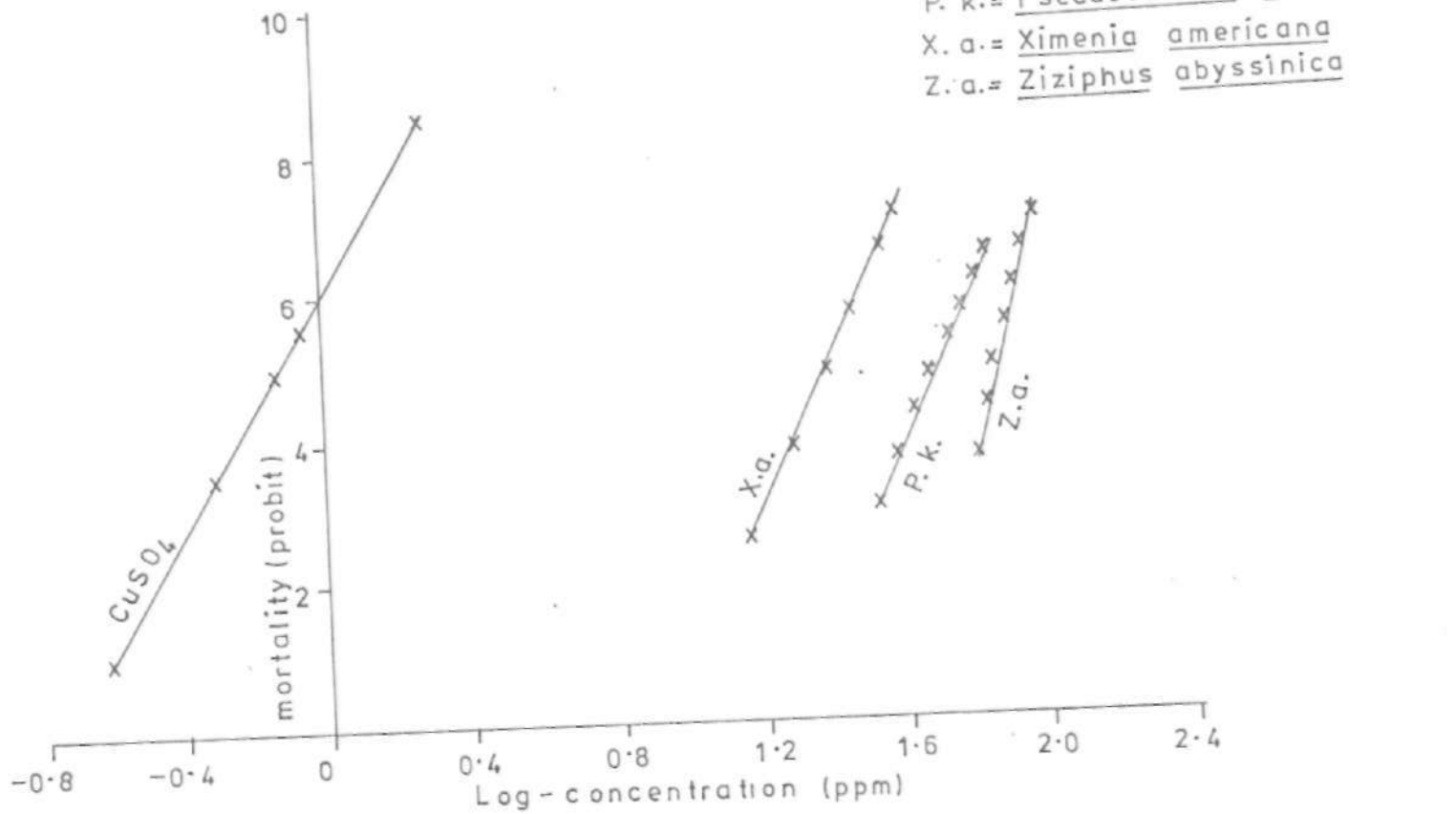


Fig. 4 Relationship of Log—concentration to mortality [probit scale] for adult L. natalensis exposed to MEOH extracts for 24 hours

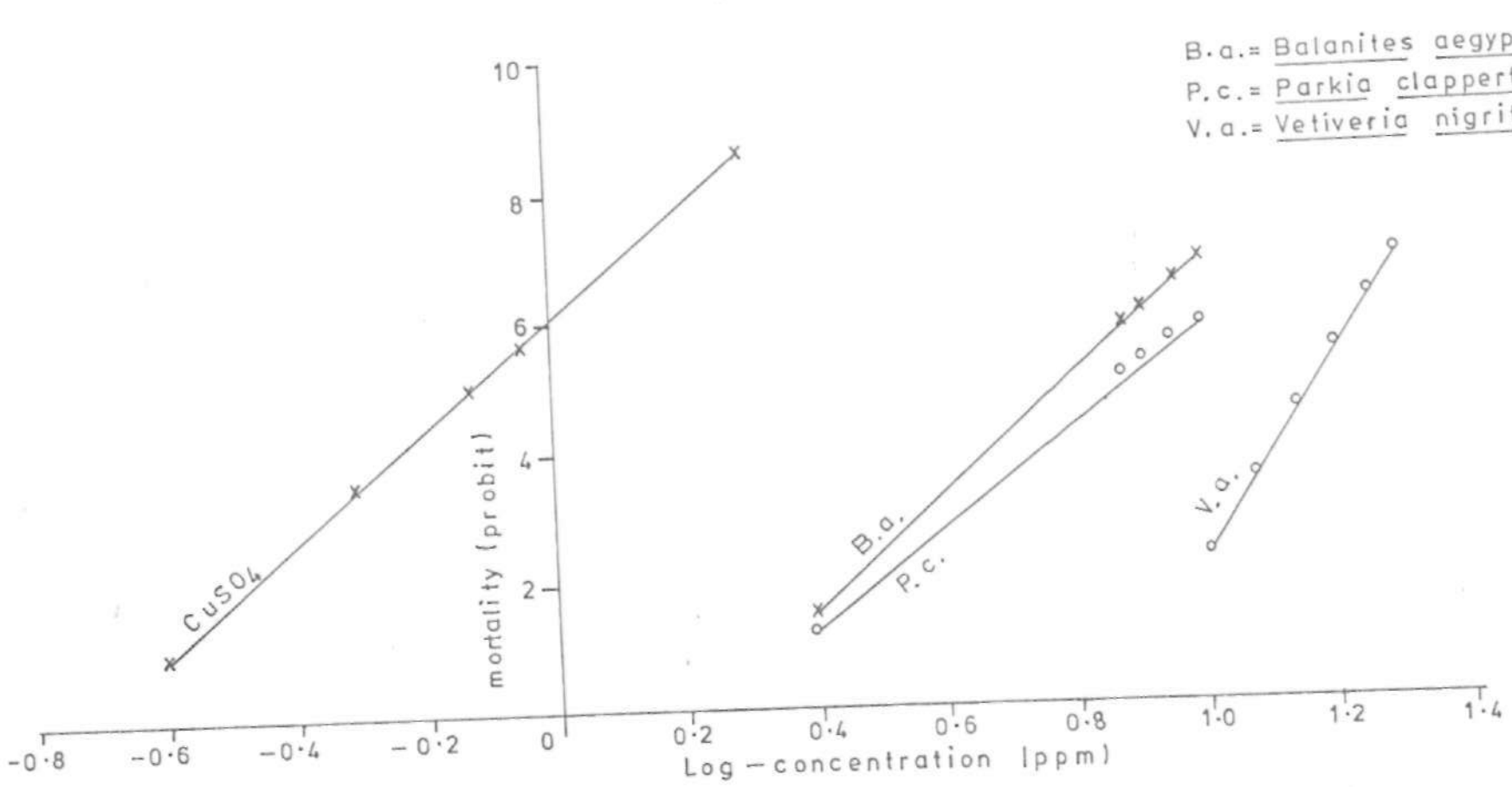


Fig. 5 Relationship of Log–concentration to mortality [probit scale] for adult L. natalensis exposed to ECW extracts for 24 hours

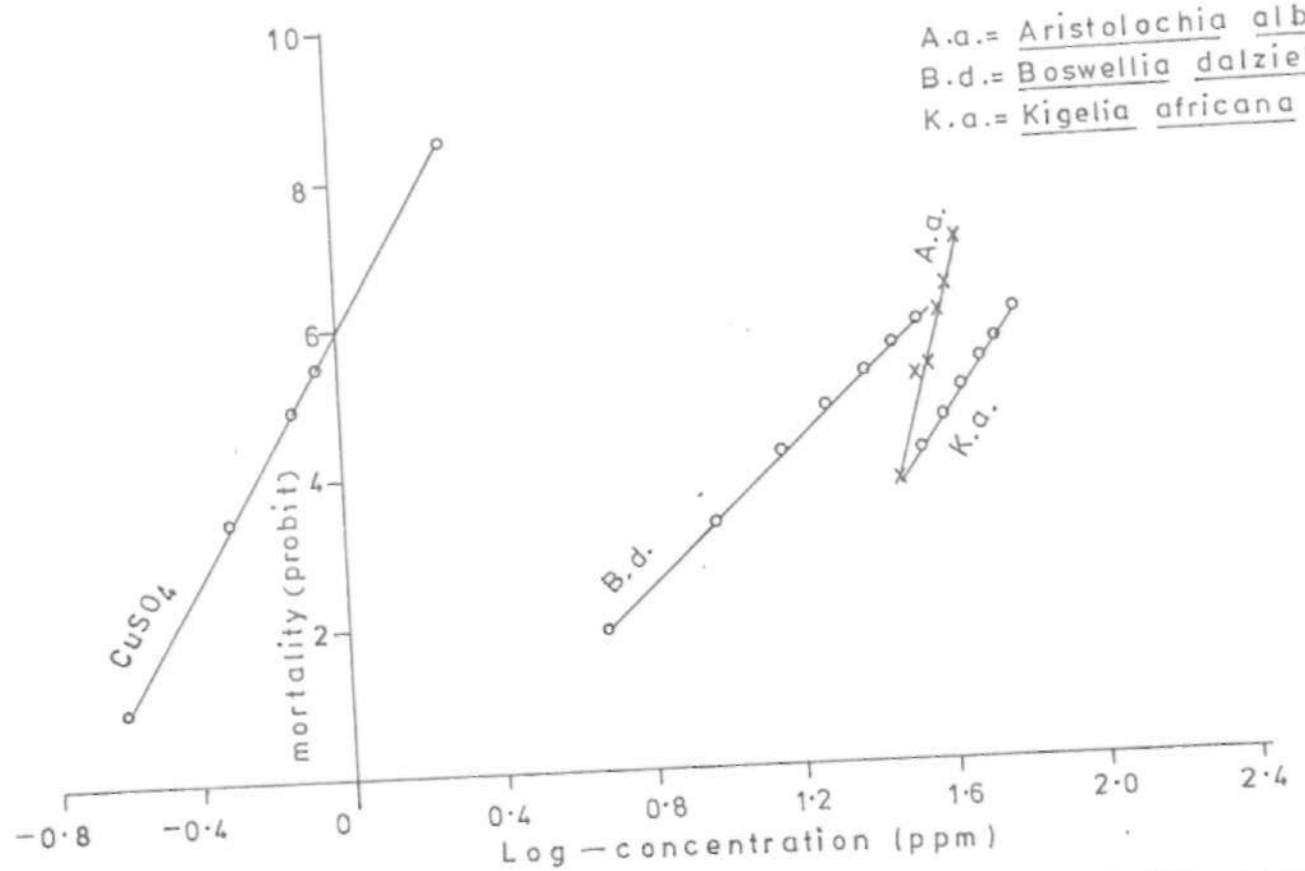
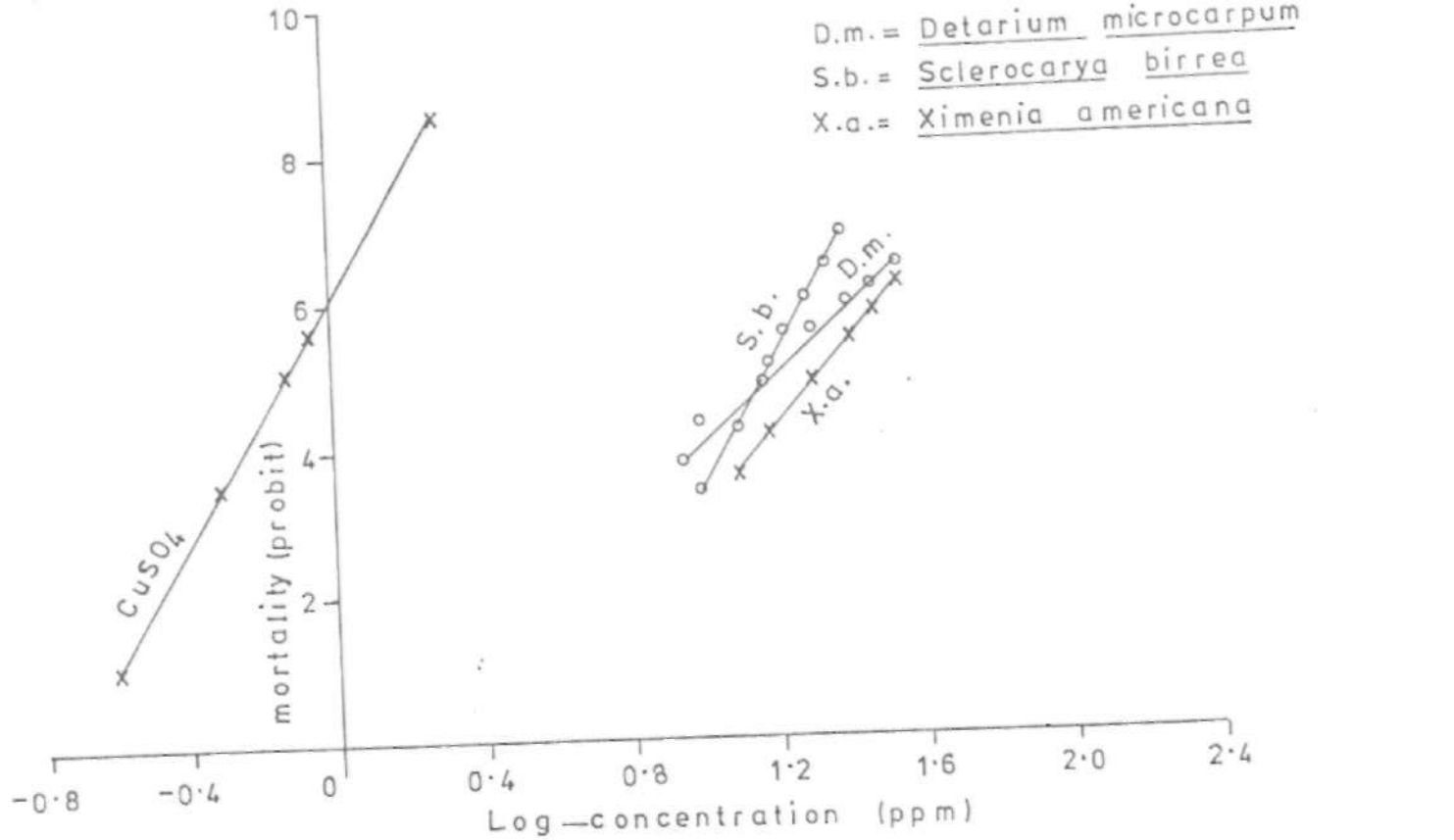


Fig. 6 Relationship of Log—concentration to mortality [probit scale] for adult L. natalensis exposed to ECW extracts for 24 hours



D.m. = Detarium microcarpum
S.b. = Sclerocarya birrea
X.a. = Ximenia americana

Fig. 7 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to ECW extracts for 24 hours

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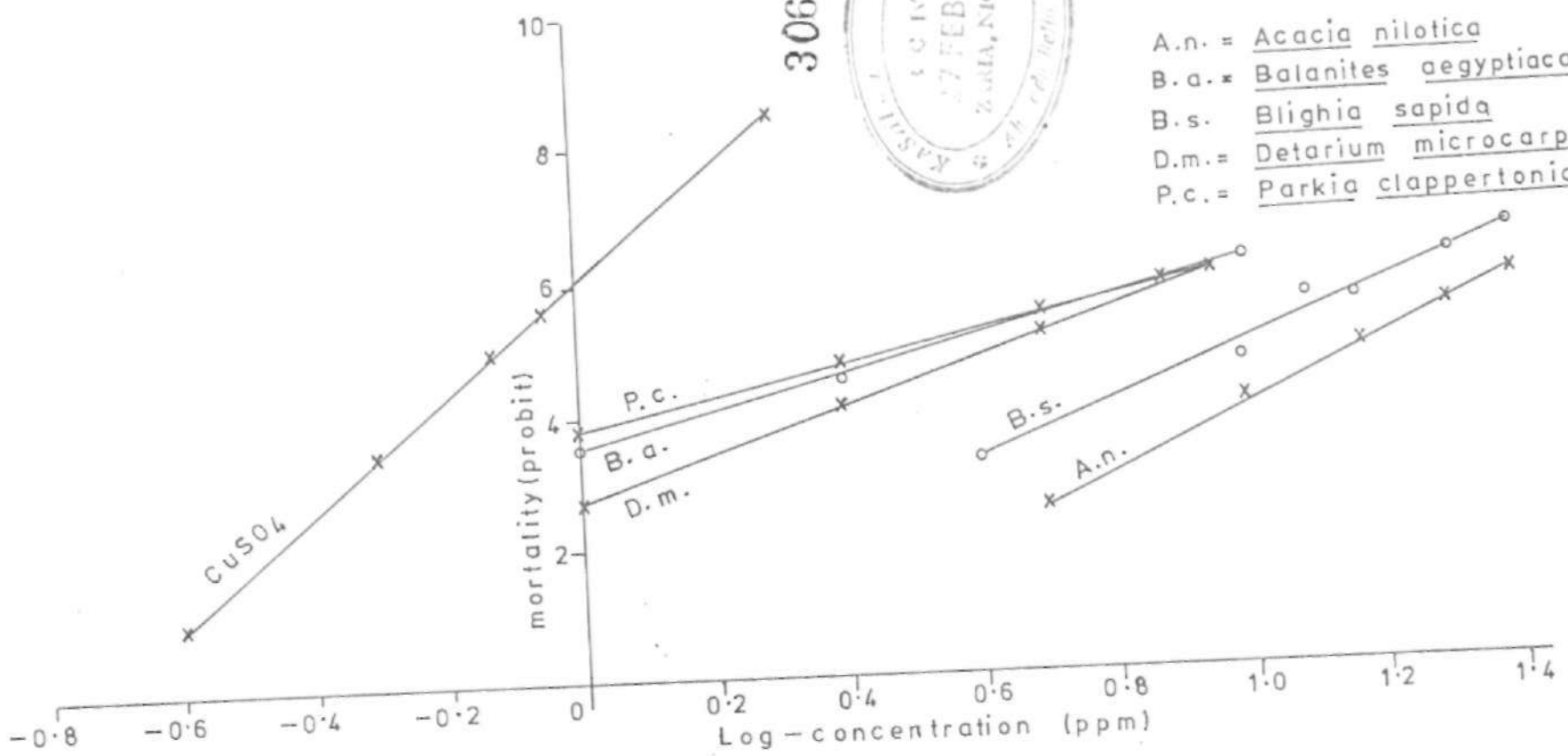


Fig. 8 Relationship of Log−concentration to mortality [probit scale] for adult L. natalensis exposed to UECW extracts for 24 hours

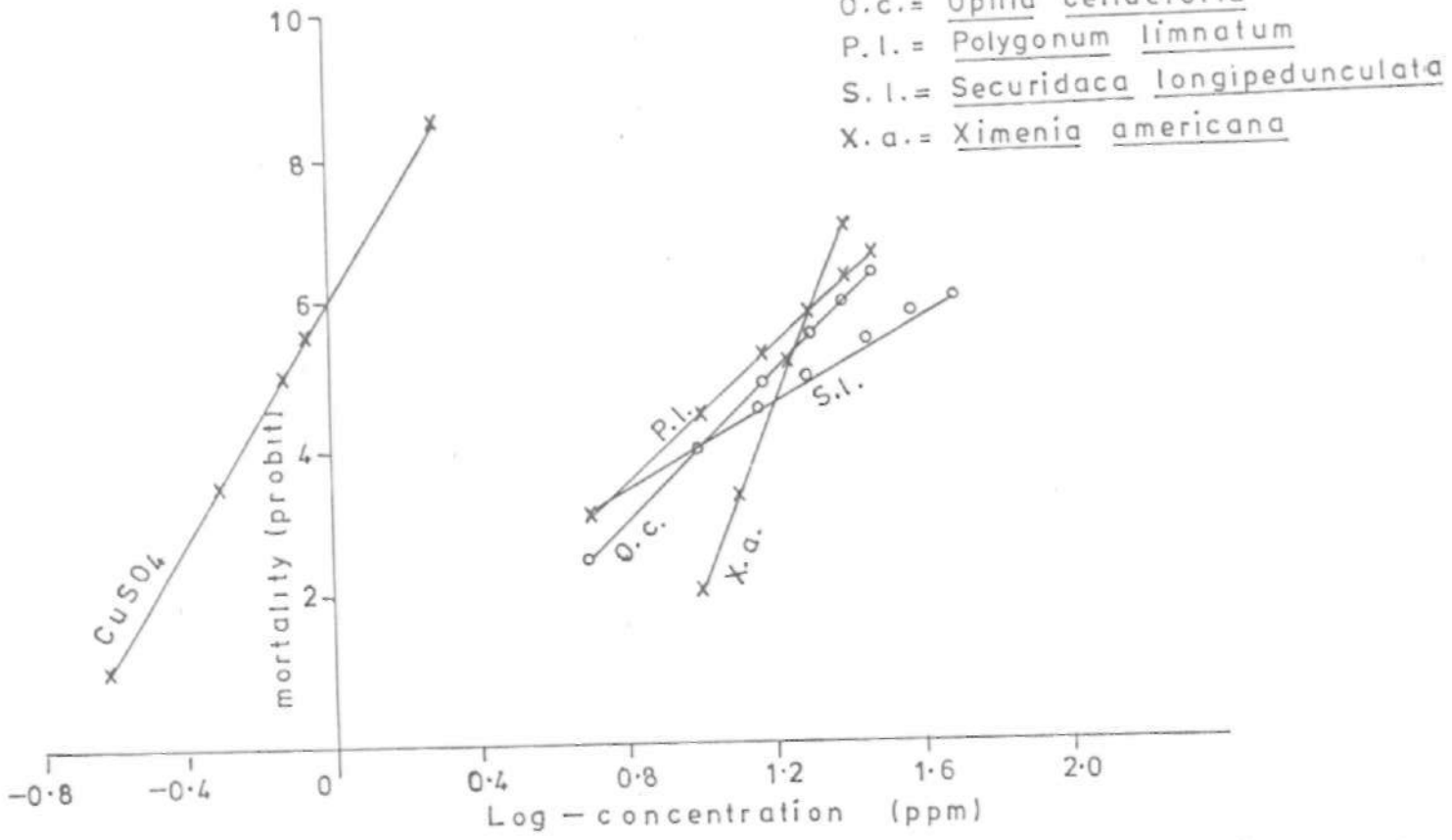


Fig. 9 Relationship of Log—concentration to mortality [probit scale] for adult L. natalensis exposed to UECW extracts for 24 hours

B.d.= Boswellia dalzielii
N.l. = Nauclea latifalia
P.k.= Pseudocedrela kotschyi
V.n. = Vetiveria nigritana

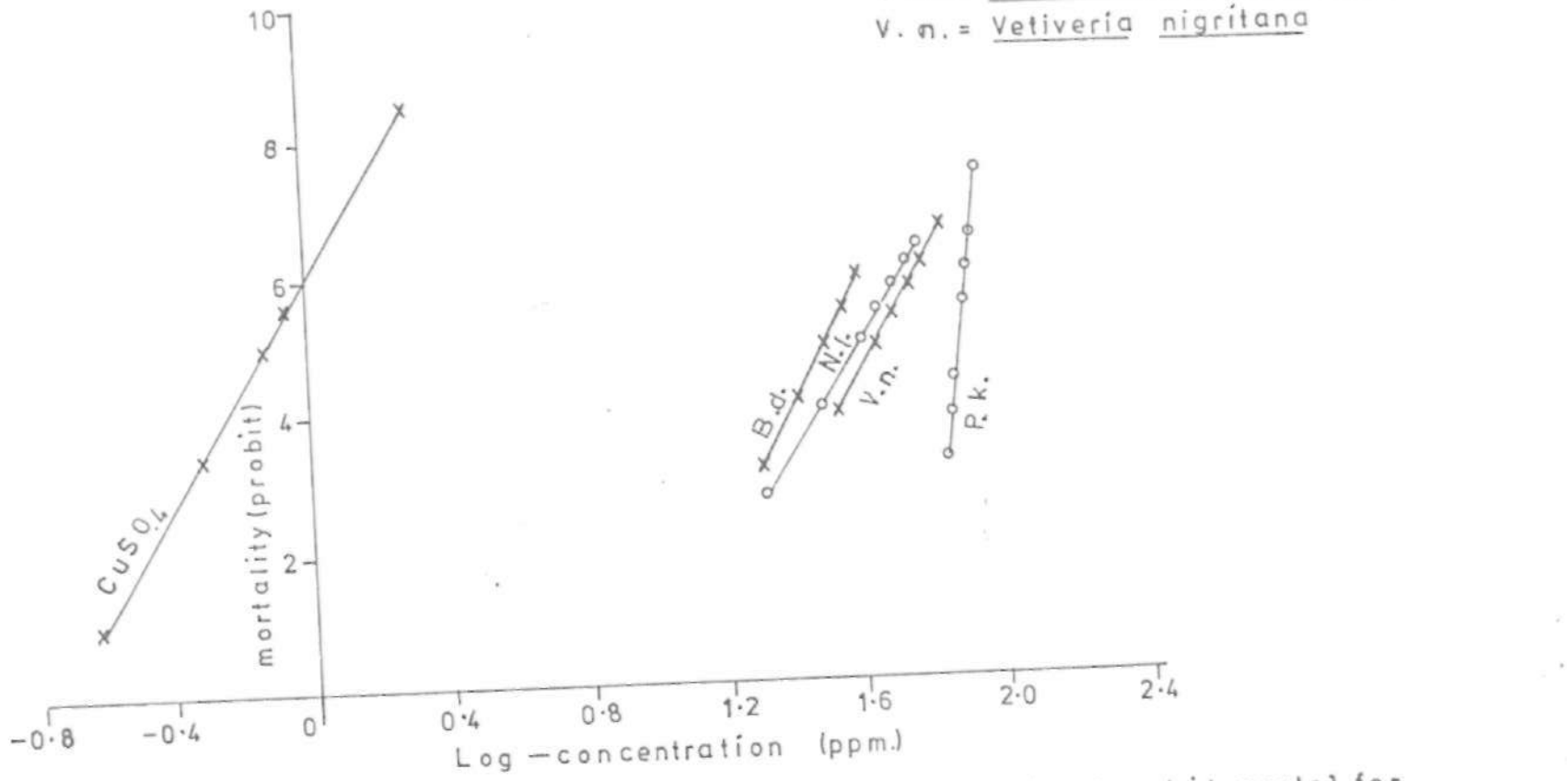


Fig.10 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to UECW extracts for 24 hours

A.a.= Aristolochia albida
G. k.= Gnidia kraussiana
K. a.= Kigelia africana

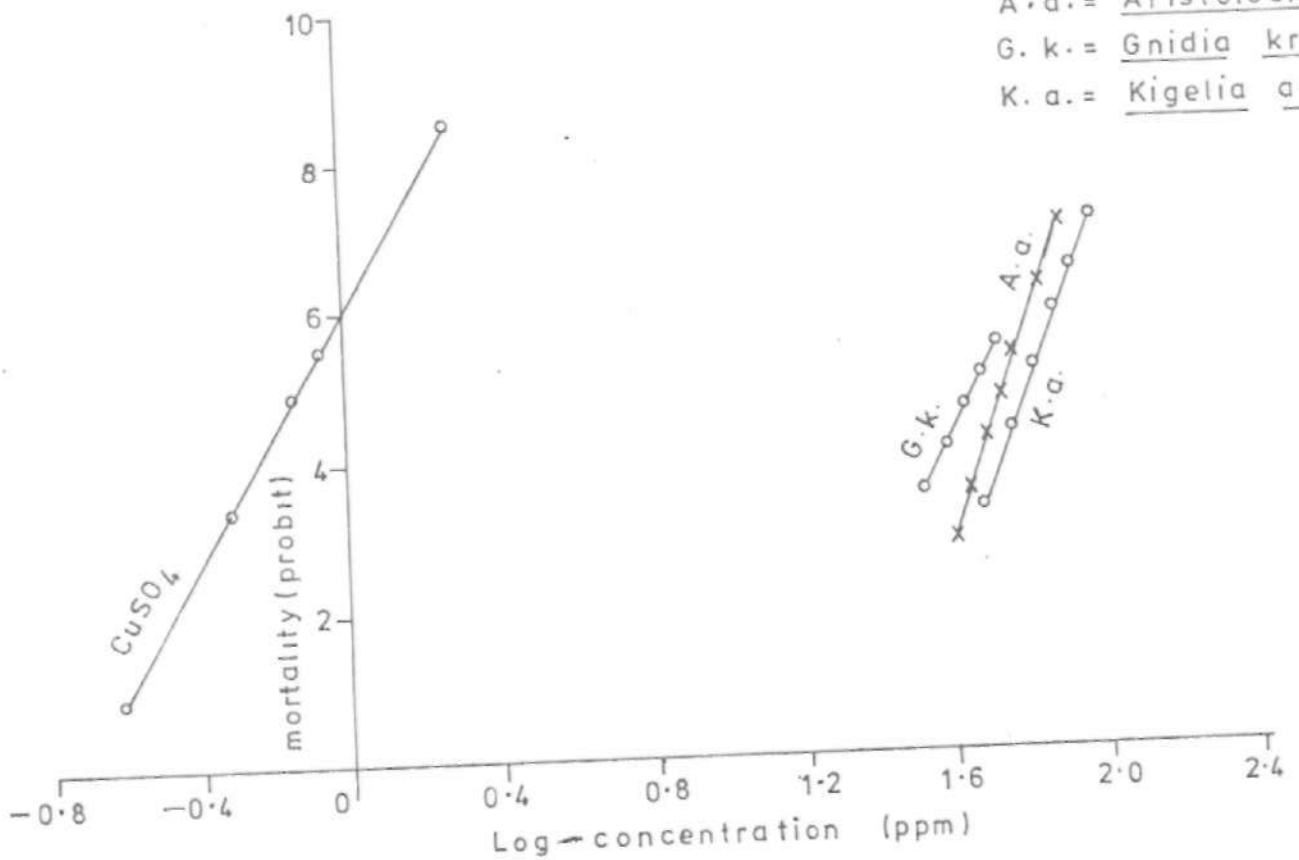


Fig. 11 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to UECW extracts for 24 hours

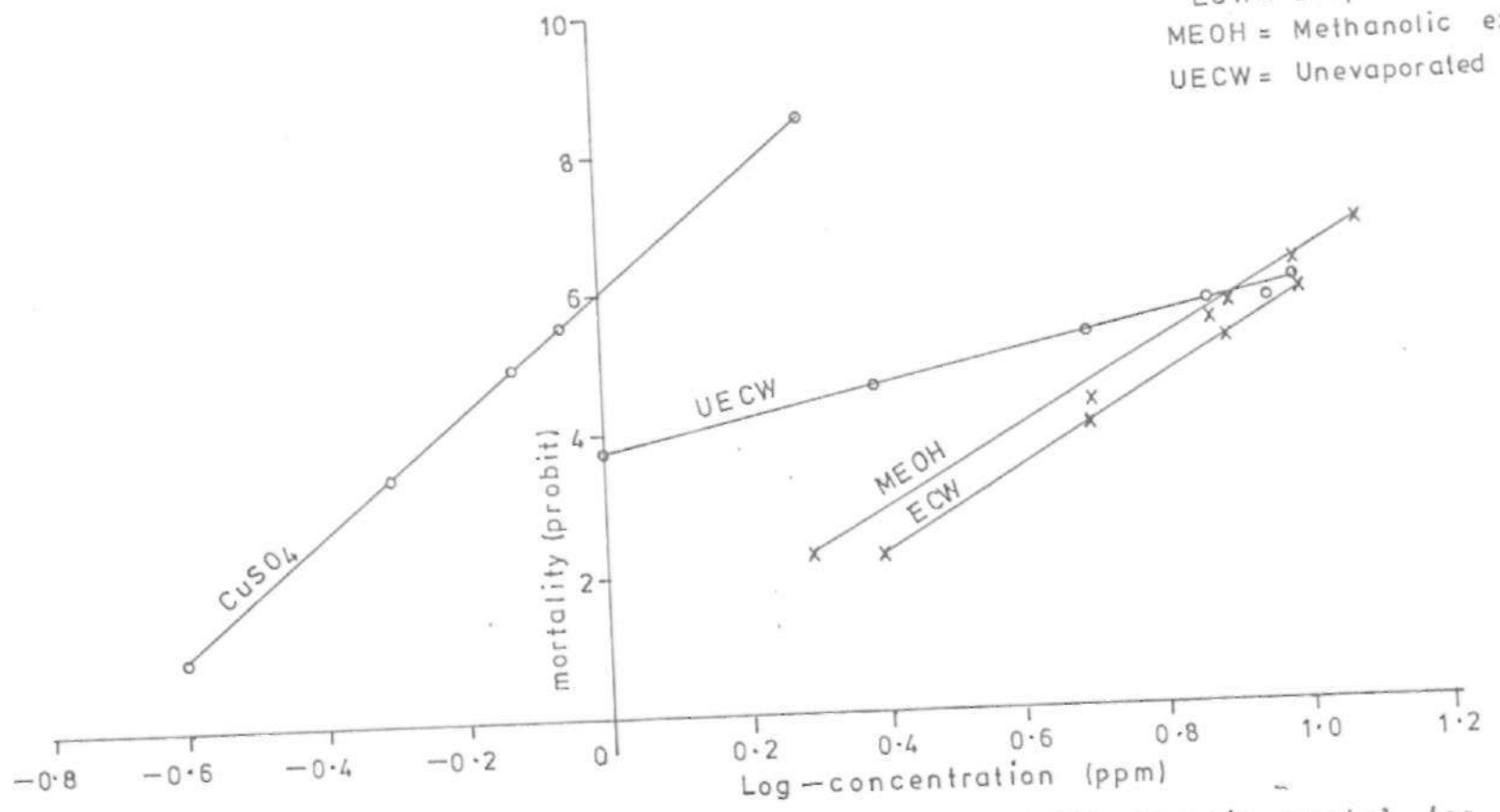


Fig.12 Relationship of Log−concentration to mortality [probit scale] for adult L. natalensis exposed to Parkia clappertoniana extracts for 24 hours

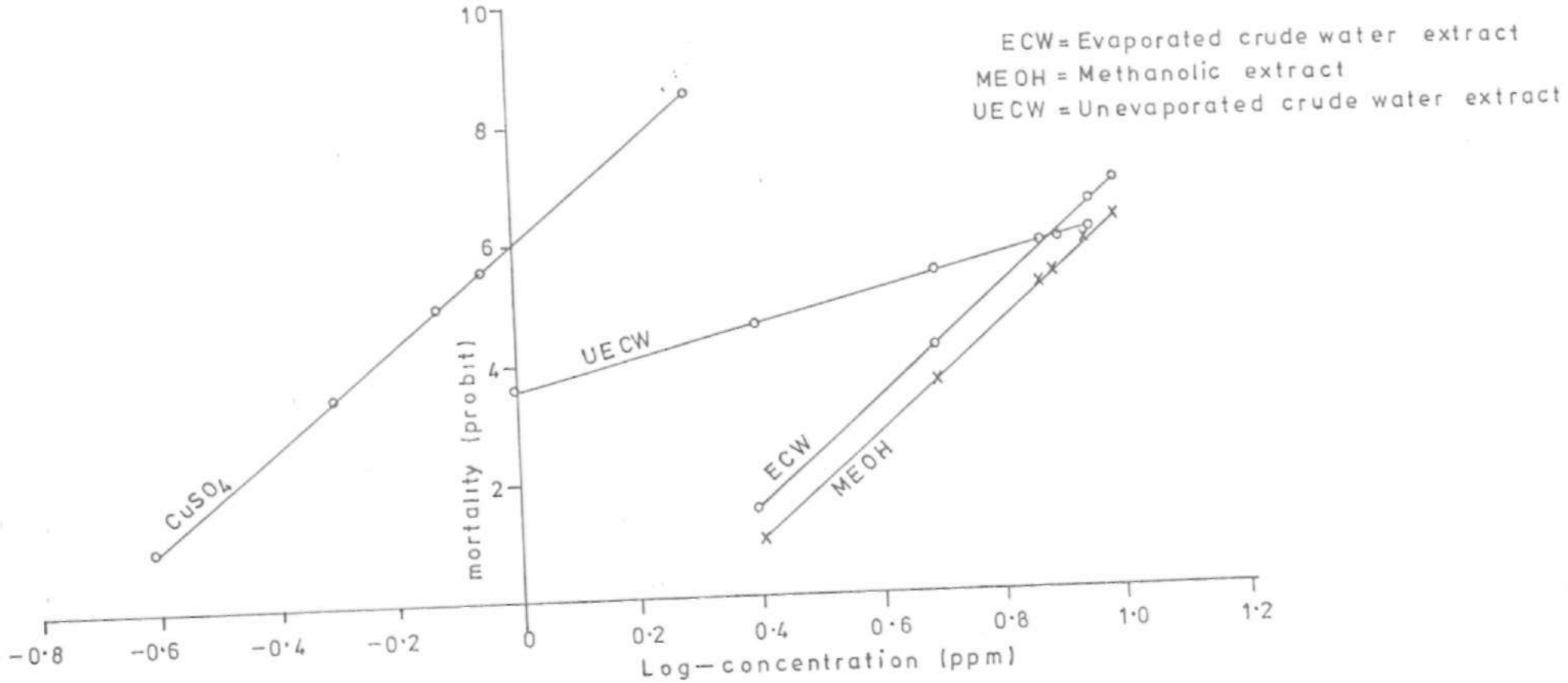
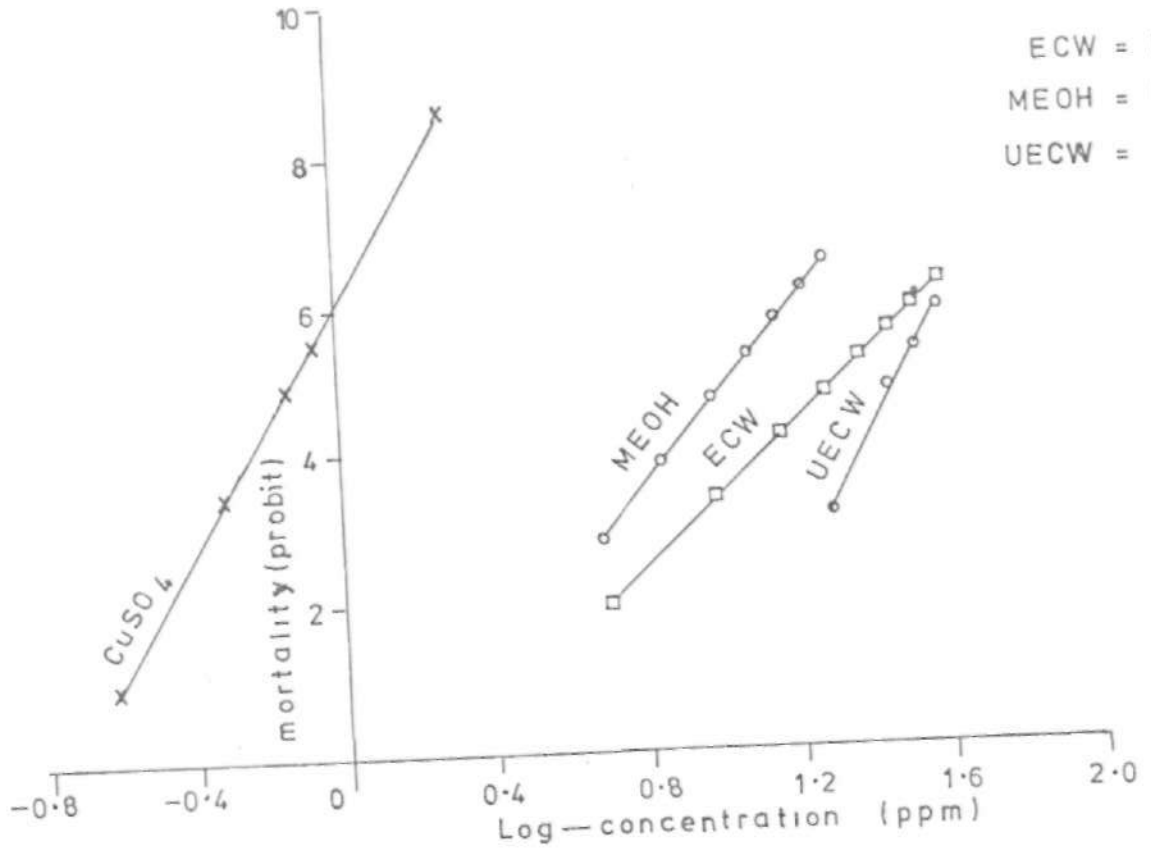


Fig.13 Relationship of Log−concentration to mortality [probit scale] for adult L. natalensis exposed to Balanites aegyptiaca extracts for 24 hours



ECW = Evaporated crude water extract
MEOH = Methanolic extract
UECW = Unevaporated crude water extract

Fig. 14 Relationshjp of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to Boswellia dalielii extracts for 24 hours

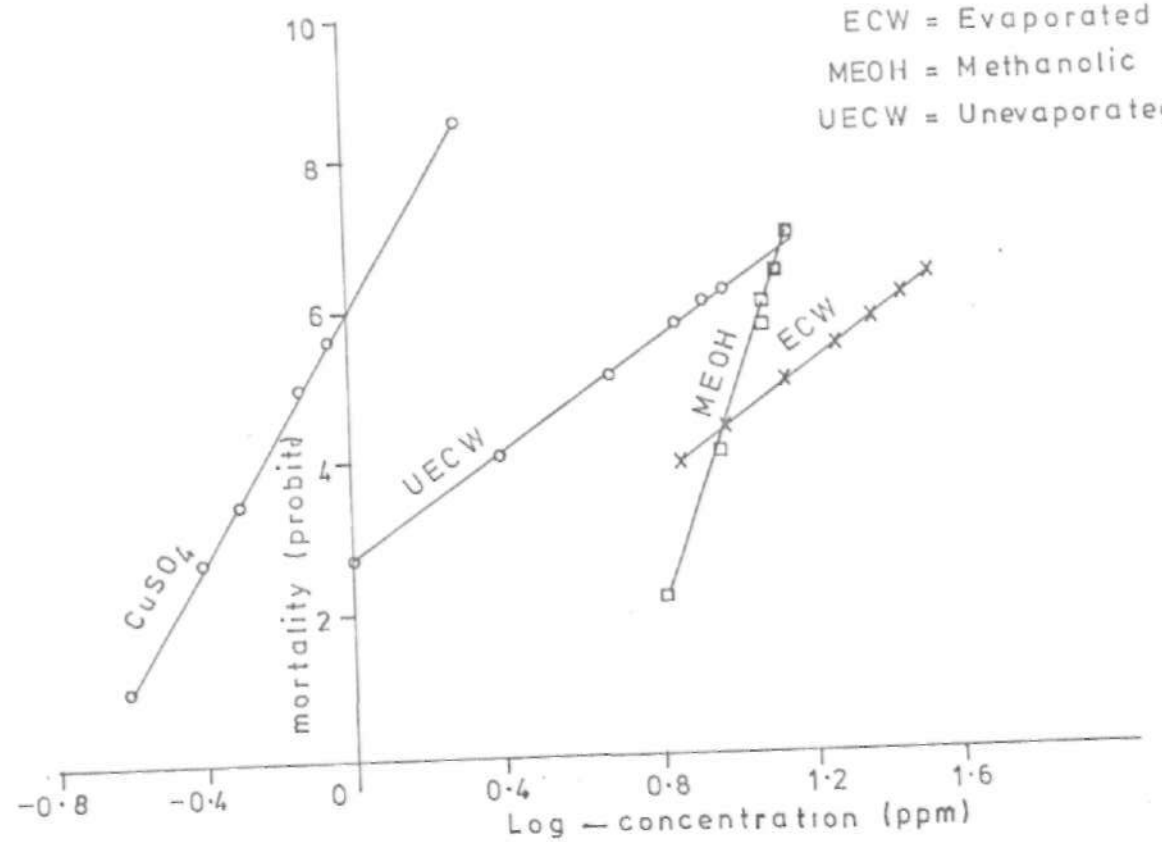


Fig. 15 Relationship of Log—concentration to mortality [probit scale] for adult L. natalensis exposed to Datarium microcarpum extracts for 24 hours

ECW = Evaporated crude water extract
MEOH = Methanolic extract
UECW = Unevaporated crude water extract

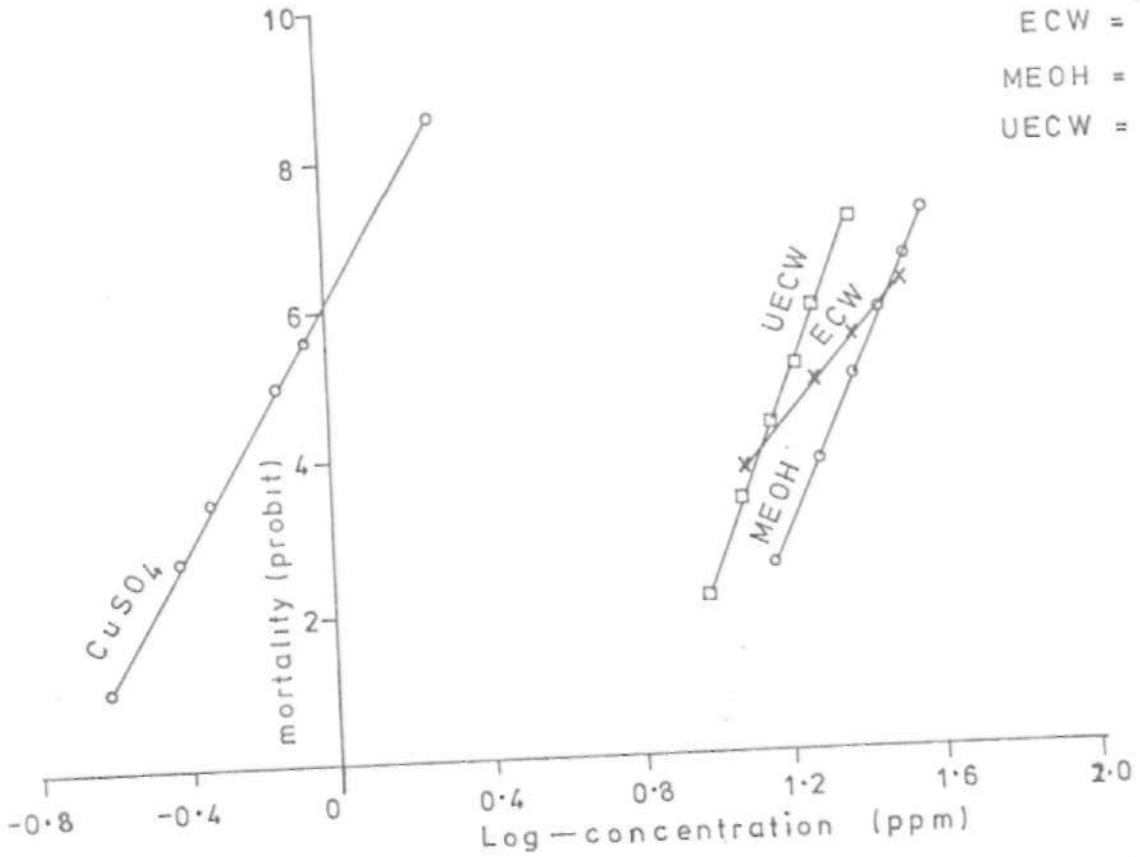


Fig.16 Relationship of Log — concentration to mortality [probit scale] for adult L. natalensis exposed to Ximenia americana extracts for 24 hours

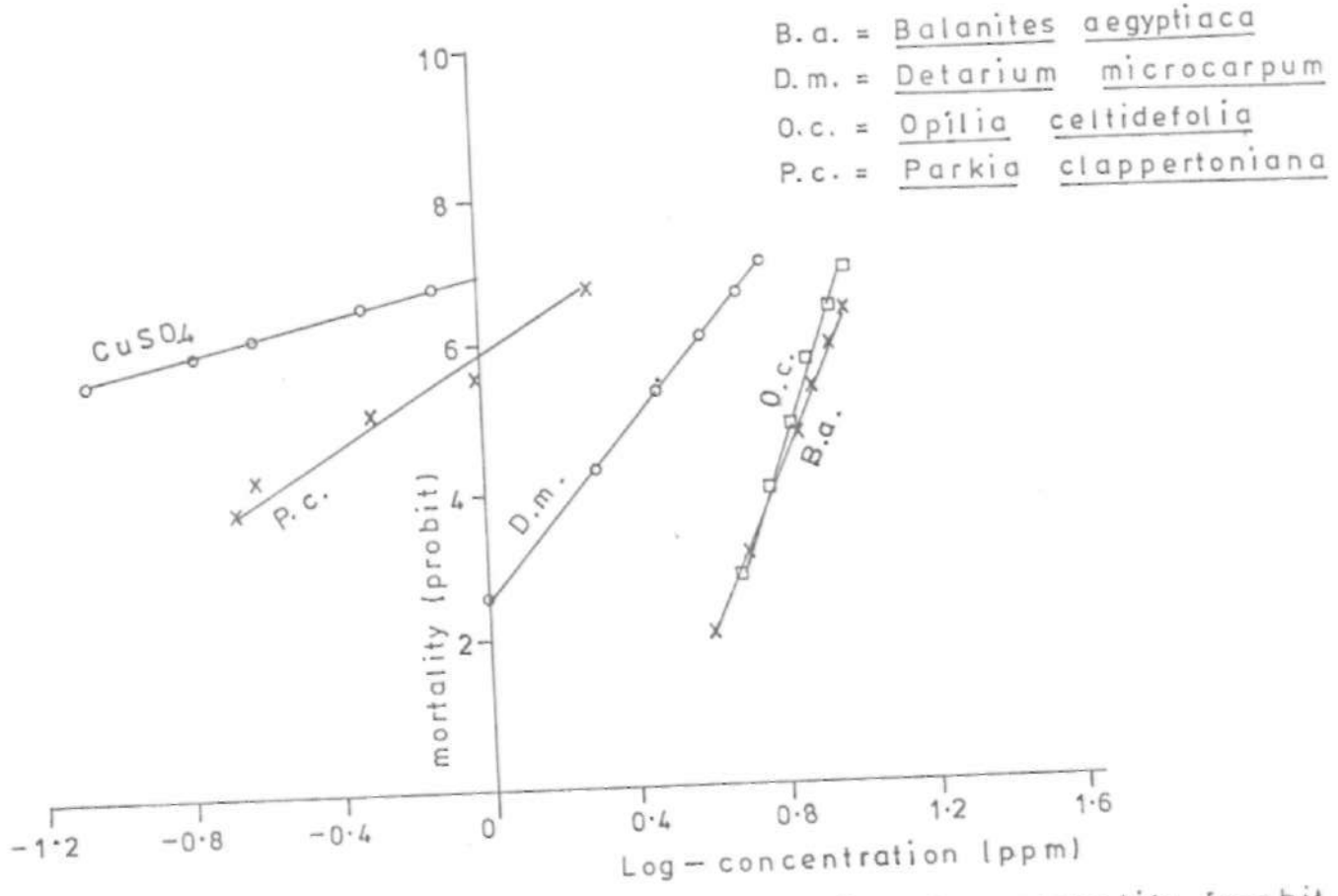
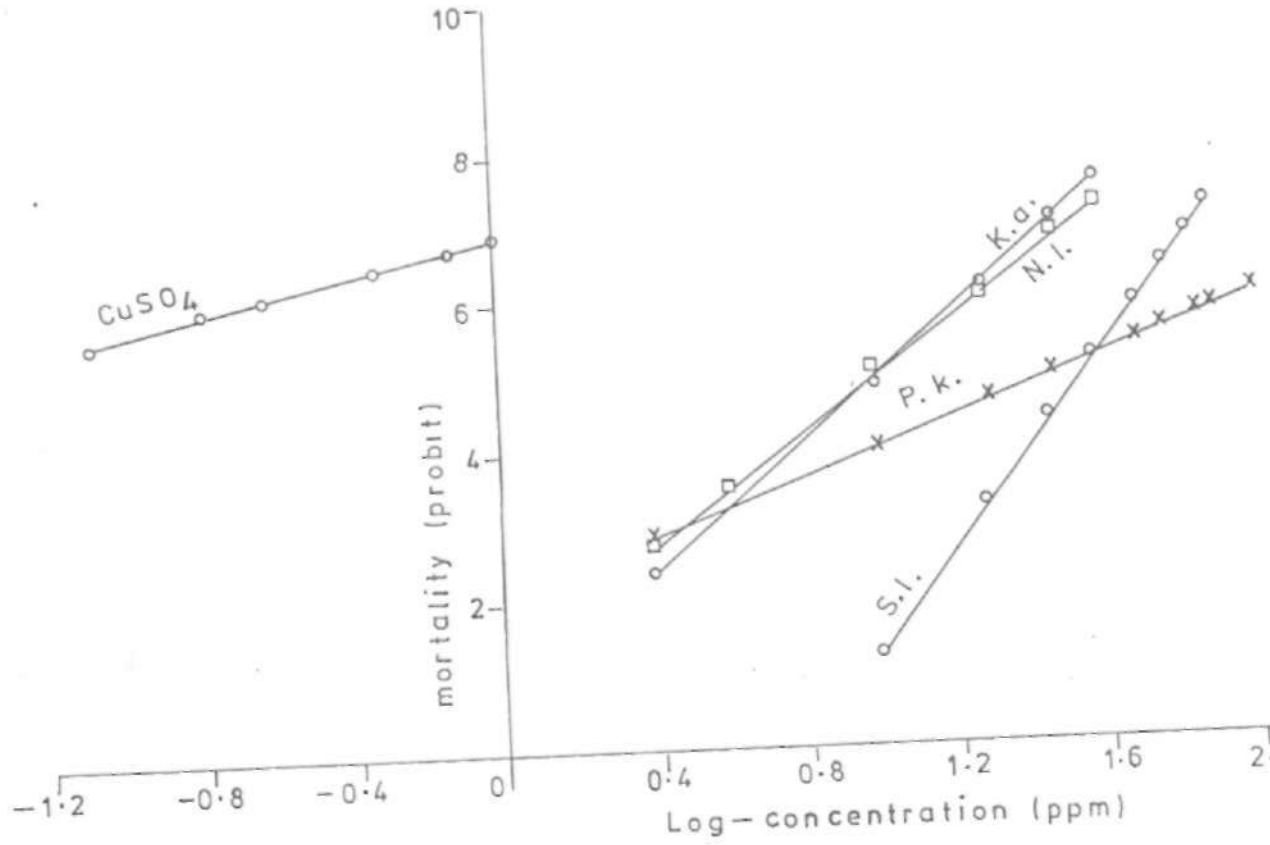


Fig. 17 Relationship of Log — concentration to mortality (probit scale for 2 — week old L. natalensis exposed to UECW extracts for 24 hours



K. a. = Kigelia africana
N. l. = Nauclea latifalia
P. k. = Pseudocedrela kotschyi
S. l. = Securidaca longipedunculata

Fig. 18 Relationship of Log — concentration to mortality [probit scale] for 2-week old L. natalensis exposed to UECW extracts for 24 hours

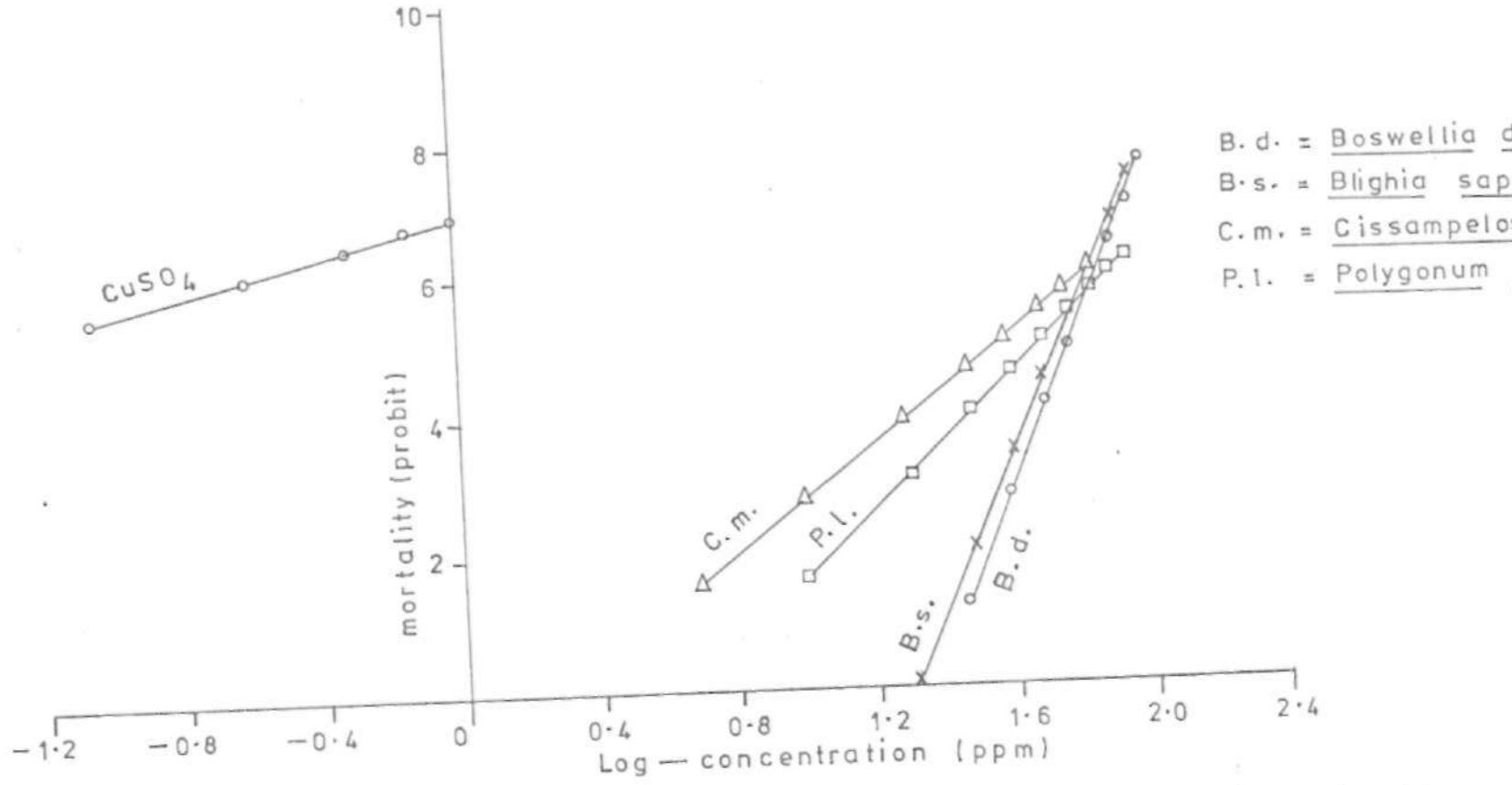


Fig. 19 Relationship of Log-concentration to mortality [probit scale for 2—week old L. natalensis exposed to UECW extracts for 24 hours

CHAPTER FIVE

D I S C U S S I O N

It is generally agreed that control of the snail intermediate hosts is an effective means of reducing the transmission of trematode diseases. The possibility that vegetable molluscicides may be of value in the control of snails was suggested by Lemma (1965) when he made direct observation of the molluscicidal effect of Endod on schistosome-transmitting snails. The results obtained from the present study have confirmed this possibility. Thus, based on the standardized method proposed by WHO (1965, 1983) for preliminary screening of potential plant molluscicides, 18 (72%) of the 25 plants screened during the present study had molluscicidal effects on adult L. natalensis. One of the problems envisaged in the use of plant molluscicides in the control of snails is the choice of solvent for extracting active plant materials. Lemma and Heyneman (1975) and Dossaji et al. (1977) reported that water may be a good universal solvent for extracting plant materials. WHO (1983) advocates the use of water as the extracting medium. From

results obtained here, activity recorded for the different types of extraction methods show that the UECW extracts had 16 (64%), the ECW extracts had 9 (36%) and the MEOH extracts had 13 (52%). This clearly shows that water as an extraction solvent for plant molluscicides was superior to methanol. This would appear to suggest that potential active ingredients in the plants are water soluble. This is encouraging since the use of plant molluscicides is more likely to be undertaken in rural areas where use of special solvents and sophisticated technology may not be feasible.

MEOH extracts of A. nilotica, B. sapida, D. microcarpum, P. clappertoniana, S. birrea and X. americana were not more potent than the water extracts. On the other hand, it was observed that the MEOH extracts of B. dalzielii, G. kraussiana, P. kotschyi and Z. abyssinica were more potent than their UECW extracts. It may likely be that molluscicidal activity of some plants is either enhanced or diminished depending on the solvent used, or the different solvents released different amounts of the active ingredients in the plants. This calls for using different solvents during extraction so as to determine the one that gives better results.

Lemma et al. (1972) reported that butanol improved the potency of P. dodecandra.

Results obtained in this study show that some of the plants apparently recorded as being non-molluscicidal at 100 ppm were active at higher concentrations.

Apart from the type of solvent, another parameter that might have affected the potency of some extracts is temperature. Non-molluscicidal activity reported with the ECW extracts of A. nilotica, G. kraussiana, N. latifolia, P. limnatum and P. kotschyi may be due to the 80°C used in extraction. This temperature could have denatured the active ingredients. Similar observations have been made on extracts of P. dodecandra (Lemma & Heyneman, 1975) and Swartzia madagascariensis (Liwihula, personal communication). For those plants whose ECW extracts had molluscicidal activity, it may be suggested that the active ingredients were stable.

It has been suggested that molluscicidal activity of plants are not restricted to any morphological part of the plant (Adewumi & Safowora, 1980). In a preliminary screening test on B. globosus, these

workers reported 10% mortality with the methanolic extract of the fruit of K. africana. The results obtained from the present study show that MEOH, ECW and UECW extracts of the bark of the same plant had 45%, 100% and 100% mortality respectively on L. natalensis. This may suggest that the active molluscicidal compound is more concentrated at the bark of the plant. Lack of molluscicidal activity by P. africana observed during the present study contrasts with observations made for the same plant by Felker and Bandursky (1979) who found it to be toxic on B. globosus.

P. africana which exhibit properties toxic to B. globosus (Felker & Bandursky, 1979), may be due to two reasons. This may be due to the fact that the unripe pod of P. africana used for this study could have contained less molluscicidal active compounds. Secondly, L. natalensis may be less susceptible to extracts of P. africana. Screening of the ripe pod of this plant on L. natalensis as done on B. globosus by Felker and Bandursky (1979) is however recommended to ascertain these claims.

One major problem in the control of snail-borne diseases is that different species of snails differ in their susceptibility to different molluscicides

(Lemma, 1970; Lemma & Yau, 1974; Dossaji et al., 1977). Most of the reported work on trials of plant molluscicides have been on the genera Biomphalaria and Bulinus snail intermediate hosts of schistosomiasis (Kloos & McCullough, 1982). B. aegyptiaca, B. maughamii, P. clappertoniana, S. longipedunculata and X.americana have been reported to be molluscicidal on these species of snails. The present work has confirmed that these plants also have molluscicidal effect on L. natalensis. This is encouraging since some of these plants can be used in the integrated control of fascioliasis and schistosomiasis in endemic foci.

A. nilotica, C. quadrangularis, L. cylindrica; P. limnatum and Z. abyssinica have not been tested previously for molluscicidal activities, though activities of Acacia dudgeoni, Cissus papulnea, Luffa operculata, Polygonum senegalensis and Ziziphus jaozero have been reported. Barbosa and Mello (1969) reported 30% mortality of B. glabrata with water extracts of the bark of Ziziphus jaozeiro. The present work reports 100% mortality on L. natalensis at 100 ppm with the MEOH extract of the root of Z. abyssinica. Similarly, 100% activity reported with the MEOH and the UECW extracts

of the pod or A. nilotica and 0% mortality with the MEOH extract of the stem of C. quadrangularis on L. natalensis are similar to the findings of Adewumi and Safowora (1980) who tested C. papulnea and A. dudgeoni on B. globosus. Also 100% mortality at 100 ppm with the MEOH and UECW extracts of the leaves of P. limnatum observed during the present study is similar to that obtained by Dossaji et al. (1977) who worked with water extract of P. senegalensis on B. pfeifferi and L. natalensis. However, the 100% activity at 100 ppm reported with water extract of the fruit of Luffa cylindrica contrasts with the 60% activity of water extract of the fruit of Luffa operculata on B. stramina reported by Silva et al. (1971). These variations could be due to the ecotype of the plants and the plant and snail species used.

Some plant molluscicides have been studied and the chemical basis of their action identified. Ambrosin, damsin and tribromo-damsin are responsible for the molluscicidal action of A. maritima (Abu-Shady & Soine, 1953). Similarly, flavonol glycoside, a cynogenic compound has been reported as the active material of P. senegalensis (Dossaji et al., 1977; Hostettmann et al., 1982); whereas the triterpenoid

saponin, oleanolic acid glucoside has been identified as the active material for the molluscicidal action of Polygonum barbatum (Parkhurst et al., 1974; Hostettmann et al., 1978). A variety of other plants including B. aegyptiaca have saponins as their molluscicidal compounds (McCullough et al., 1980). Mortalities of B. globosus and P. planorbis due to extract of B. aegyptiaca was caused by saponins. These compounds could have been the active ingredients responsible for L. natalensis mortality in P. limnatum and, A. nilotica, B. sapida, L. cylindrica, O. celtidefolia and S. longipedunculata which had characteristic foamy extracts. It is probable that disterpene present in G. kraussiana (Nwude, 1976) could have been the cause of L. natalensis mortality in extract of this plant.

It has been observed that molluscicides cause stress on the water balance system by lowering the surface tension (McCullough et al., 1980). This could have accounted for the rapid submergence of snails in extracts and to some extent the cause of snail mortality observed during the present study. Poisoning which caused snails to expel haemolymph could be due to destruction of the blood system by

extracts. Poisoning in snails which extend from shell opening is due both to extract which act on the central nervous system (CNS) leading to loss of water balance control, and inhibition of the enzymatic activity of the snails (McCullough et al., 1980). It has also been documented by these workers that death caused by $CuSO_4$ is due to inhibition of the enzymatic sulfydryl group. It could be speculated that extracts of B. dalzielii, D. microcarpum, K. africana, P. clappertoniana and P. kotschyi whose mode of action caused snails to remain extended out of shell opening could be neuro-toxic in action. Apparently, saponins responsible for activity in B. aegyptiaca (Hostettman et al., 1982) has a similar mode of action.

Nwude (1976) reported nasal and ocular discharges in test animals exposed to Lasiosiphon kraussianus (= G. kraussiana) which he attributed to irritation by toxins reaching the nose and the eye through the blood capillaries. This could be the cause of burning sensation experienced by any one while extracting and screening this plant.

The relative toxicity of extracts obtained by any of the three extraction methods and $CuSO_4$ on

adult snails (Figs 1 - 11) are encouraging, as the log-concentration mortality plot for most extracts were close to the origin (Figs 1, 5 and 8). Similarly, gradient of the lines and their relationship to that for $CuSO_4$ differ, suggesting differences in toxicity of extracts and the reference molluscicide. A similar observation has been reported by Baalawy (1972) for Endod extract on Biomphalaria and Bulinus snails. Since molluscicides are affected by various environmental factors, viz, organic matter, pH and ultra violet (UV) light (WHO, 1965; Lemma & Yau, 1974), it follows that differences in stability will result in different field application depending on the local environmental conditions. The MEOH extracts of A. nilotica, D. microcarpum, Z. abyssinica; the ECW extracts of A. albida, K. africana, P. kotschyi and X. americana which produced steep slopes suggest that the concentration of extracts and duration of application have to be increased to obtain maximum control of L. natalensis in field trials. MEOH extracts of P. limnatum, P. kotschyi, S. birrea which had parallel lines to $CuSO_4$ indicates that they act in like manner with this reference standard molluscicide. It could be deduced from the graphs that there is no apparent toxic difference

between using the MEOH and the UECW extracts of B. aegyptiaca since at about 10 ppm both extracts caused about the same mortality rates. Above 10 ppm on the other hand, the MEOH extract of B. aegyptiaca appears superior to the UECW extract as confirmed by the LC_{90} and LC_{95} values (Tables 7 and 8). Similarly, MEOH extract of D. microcarpum appears superior to that of B. dalzielii above 10 ppm as it produced high mortality rates for small increase in concentration.

UECW extracts of A. nilotica, A. albida, G. kraussiana, V. nigritana and X. americana were non-toxic to young snails at the concentration at which they were toxic to adult ones. This suggests that young L. natalensis are less susceptible than adult ones to these extracts.

Although log-concentration mortality plot for UECW extracts on young snails were not parallel to that for $CuSO_4$, the distance between the origin and the foot of each line especially for B. aegyptiaca, D. microcarpum, K. africana, N. latifolia, P. clappertoniana and P. kotschyi are comparable to $CuSO_4$. This suggests that although the way in which these extracts act differ from each other and from

$CuSO_4$, their toxicities on young L. natalensis are good when compared to $CuSO_4$ the reference molluscicide.

Differences in steepness and slope effects of the lines indicate the extent to which increase in concentration of extracts should be done to secure an increase in response (Brander & Pugh, 1977). Accordingly, the concentration of B. aegyptiaca, O. celtidefolia (Fig 17); S. longipedunculata (Fig 18), and B. sapida and B. dalzielii (Fig 19) which have steep lines compared to the other extracts and $CuSO_4$, have to be increased for desirable results on young snails.

SUMMARY AND CONCLUSION

The molluscicidal activities of 25 Nigerian plants were evaluated on L. natalensis using three extraction methods. Overall activity by WHO (1965, 1983) standards with extracts from at least one of the extraction method used were recorded in 18 (72%).

Some of the reported variations in toxicity between the plants studied were probably due to extraction method, solvents used and temperature.

The study confirmed molluscicidal activity of some plant extracts on L. natalensis some of which have not been reported in the literature to be molluscicidal on the genera Biomphalaria and Bulinus snails.

Peculiar protective behavior of L. natalensis observed in test solutions during toxicity tests may lead to failure of field control programmes. This could be overcome by increasing concentration of extracts and duration of application.

To broaden the scope of this study so as to achieve the goal for ideal plant molluscicides of

acceptable effectiveness, further work is recommended on the chemical basis of the active compound(s) of all molluscicidal plants reported by use of the UECW extraction method.

Toxicological investigations on the cercaricidal, ovicidal and piscicidal effects of these extracts at the molluscicidal concentration may lead to effective field control programmes of L. natalensis, other snail intermediate hosts and the trematode diseases they transmit.

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Appendix I

1. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extract of Acacia nilotica for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated].**

Conc. in (ppm)	Log Conc.	Mortality *		Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
75.0	1.8751	(0)	0	3.7496	3.5	10.5	0.0521
77.5	1.8893	(5)	25	4.3523	25.0	25.9	0.0004
80.0	1.9031	(12)	60	4.9358	60.0	47.4	0.0637
82.5	1.9165	(14)	70	5.5014	70.0	69.2	0.0003
85.0	1.9294	(16)	80	6.0501	80.0	85.3	0.0224
87.5	1.9420	(19)	95	6.5829	95.0	94.3	0.0009
90.0	1.9542	(20)	100	7.1007	99.3	98.2	0.0068

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd. 2. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extract of Balanites aegyptiaca for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated].

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	1.0234	0.3	0.1	0.0040
5.0	0.6990	(2) 10	3.6078	10.0	8.2	0.0043
7.5	0.8751	(8) 40	5.1195	40.0	54.7	0.0872
8.0	0.9031	(13) 65	5.3602	65.0	64.1	0.0004
9.0	0.9541	(17) 85	5.7993	85.0	78.8	0.0230
10.0	1.0000	(20) 100	6.1921	88.3	88.3	0.0000

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd. 3. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentration of MEOH extract of Blighia sapida for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated].**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.000	(0) 0	3.7609	3.5	10.8	0.0553
15.0	1.1761	(6) 30	4.6862	30.0	37.7	0.0252
20.0	1.3010	(12) 60	5.3426	60.0	62.4	0.0050
25.0	1.3979	(16) 80	5.8518	80.0	80.3	0.0001
30.0	1.4771	(18) 90	6.2629	90.0	89.6	0.0002
35.0	1.5441	(19) 95	6.6196	95.0	94.7	0.0002
40.0	1.6021	(20)100	6.9243	99.0	97.3	0.0110

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd. 4. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Boswellia dalzielii for 24 hours /corrected probit, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated/**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	2.8555	0.3	0.6	0.0015
7.5	0.8751	(3) 15	3.8224	15.0	12.0	0.0085
10.0	1.0000	(7) 35	4.6936	35.0	27.2	0.0307
12.5	1.0969	(12) 60	5.2853	60.0	61.2	0.0006
15.0	1.1761	(15) 75	5.7688	75.0	77.9	0.0049
17.5	1.2430	(18) 90	6.1776	90.0	88.0	0.0038
20.0	1.3010	(20)100	6.5317	98.0	93.7	0.0313

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

5. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extract of Detarium microcarpum for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	E pected Effect	Deviation (GI)
7.5	0.8751	(0) 0	1.9823	0.3	0.2	0.0005
10.0	1.0000	(4) 20	4.0478	20.0	17.1	0.0059
12.5	1.0969	(12) 60	5.6800	60.0	74.2	0.1053
13.0	1.1139	(17) 85	5.9316	85.0	82.4	0.0047
14.5	1.1461	(19) 95	6.4636	95.0	92.8	0.0072
15.0	1.1761	(20)100	6.9590	99.0	97.5	0.0092

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

6. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Gnidia kraussiana for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated)

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	3.3369	1.6	4.8	0.0224
7.5	0.8751	(4) 20	4.0968	20.0	18.3	0.0019
10.0	1.0000	(7) 35	4.6360	35.0	35.8	0.0003
12.5	1.0969	(10) 50	5.0543	50.0	52.2	0.0019
15.0	1.1761	(12) 60	5.3960	60.0	65.4	0.0129
17.5	1.2430	(16) 80	5.6849	80.0	75.3	0.0119
20.0	1.3010	(20)100	5.9352	94.8	82.6	0.1036

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

7. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Parkia clappertoniana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	2.3653	0.3	0.2	0.0005
5.0	0.6690	(5) 25	4.3092	25.0	21.5	0.0073
7.5	0.8751	(10) 50	5.4463	50.0	67.2	0.1342
8.0	0.9031	(14) 70	5.6273	70.0	72.4	0.0029
10.0	1.0000	(18) 90	6.2531	90.0	89.6	0.0002
12.5	1.0969	(20)100	6.8788	98.7	97.0	0.0099

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

8. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Polygonum limnatum for 24 hours /corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
15.0	1.1761	(0) 0	3.4509	2.0	6.1	0.0293
17.5	1.2430	(2) 10	3.9626	10.0	15.0	0.0196
20.0	1.3010	(5) 25	4.4059	25.0	27.6	0.0034
25.0	1.3979	(8) 40	5.1466	40.0	56.2	0.1066
30.0	1.4771	(17) 85	5.7518	85.0	77.4	0.0330
35.0	1.5441	(20)100	6.2635	96.8	89.6	0.0556

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

9. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extract of Pseudocedrela kotschyi for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated]

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
35.0	1.5441	(0) 0	3.0428	1.0	2.5	0.0092
40.0	1.6021	(2) 10	3.7176	10.0	10.[illegible]	0.0000
45.0	1.6532	(4) 20	4.3128	20.0	19.3	0.0003
50.0	1.6990	(10) 50	4.8452	50.0	43.9	0.0151
55.0	1.7404	(13) 65	5.3269	65.0	62.8	0.0021
60.0	1.7782	(16) 80	5.7666	80.0	77.8	0.0028
65.0	1.8129	(17) 85	6.1710	85.0	87.9	0.0079
70.0	1.8451	(20)100	6.5455	98.0	93.9	0.0293

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

10. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Sclerocarya birrea for 24 hours [corrected probit, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated]

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
15.0	1.1761	(0) 0	3.6157	2.6	8.3	0.0427
17.5	1.2430	(3) 15	4.1212	15.0	19.0	0.0104
20.0	1.3010	(8) 40	4.5591	40.0	33.0	0.0222
22.5	1.3522	(10) 50	4.9453	50.0	47.8	0.0019
25.0	1.3979	(12) 60	5.2908	60.0	61.4	0.0008
30.0	1.4771	(16) 80	5.8887	80.0	81.3	0.0011
35.0	1.5441	(20)100	6.3942	97.7	91.8	0.0462

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

11. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Securidaca longipedunculata for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
15.0	1.1761	(0) 0	3.9071	4.4	13.7	0.0732
20.0	1.3010	(4) 20	4.7059	20.0	38.4	0.1431
25.0	1.3979	(12) 60	5.3256	60.0	62.8	0.0034
30.0	1.4771	(16) 80	5.8318	80.0	79.7	0.0001
35.0	1.5441	(18) 90	6.2599	90.0	89.6	0.0002
40.0	1.6021	(20)100	6.6307	98.4	94.9	0.0253

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

For each test concentration, four replicates of five snails each were used. Because of non-availability of Niclosamide as recommend by WHO (1981) as a reference molluscicide, $CuSO_4$ was used as the reference molluscicide and, distilled water and untreated dam water used as controls.

Before each test, the snails were washed in distilled water and blotted dry with "Whatman" filter paper. They were then exposed in the test or control medium for a 24-hour period. Observations for peculiar protective behavior of the snails were made at hourly intervals. At the end of each exposure period, snails were washed with distilled water and put in 150ml fresh distilled water for a recovery period of 48 hours as recommended by Lugt (1981). Mortality was confirmed by failure of heart-beat observed by shining light from the bottom of each experimental container using dissecting microscope and failure of snails to retract into their shell when touched with a needle after the prescribed 48-hours recovery period.

Appendix I contd.

12. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Ximenia americana for 24 hours [corrected probits, corrected effects, expected effects, and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated]

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
15.0	1.1761	(0) 0	2.4691	0.3	0.5	0.0008
20.0	1.3010	(3) 15	3.8409	15.0	12.3	0.0068
25.0	1.3979	(8) 40	4.9050	40.0	46.2	0.0155
30.0	1.4771	(15) 75	5.7744	75.0	78.1	0.0056
35.0	1.5441	(19) 95	6.5094	95.0	93.4	0.0042
40.0	1.6021	(20)100	7.1462	99.3	98.4	0.0051

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

13. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of MEOH extracts of Ziziphus abyssinica for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated]

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
65.0	1.8129	(0) 0	3.7033	3.2	9.7	0.0482
70.0	1.8451	(4) 20	4.3622	20.0	26.2	0.0199
75.0	1.8751	(12) 60	4.9757	60.0	49.0	0.0484
80.0	1.9031	(15) 75	5.5495	75.0	70.8	0.0085
85.0	1.9294	(16) 80	6.0885	80.0	86.2	0.0323
90.0	1.9542	(19) 95	6.5968	95.0	94.5	0.0005
95.0	1.9777	(20)100	7.0775	99.3	98.1	0.0077

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix I contd.

14. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of $CuSO_4$ reference molluscicide for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) of Litchfield and Wilcoxon (1949) method incorporated]**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
0.25	-0.6021	(0) 0	1.0555	0.3	0.1	0.0040
0.50	-0.3010	(2) 10	3.5531	10.0	7.4	0.0099
0.75	-0.1249	(7) 35	5.0142	35.0	50.5	0.0961
0.90	-0.0458	(15) 75	5.6711	75.0	74.9	0.0000
1.0	0.0000	(18) 90	6.0508	90.0	85.3	0.0176
2.0	0.3010	(20)100	8.5485	99.7	99.9	0.0040

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II

1. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Aristolochia albida for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log Conc.	*	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
30.0	1.4771	(0) 0	3.3667	1.6	5.1	0.0253
32.5	1.5119	(3) 15	4.0538	15.0	17.0	0.0034
35.0	1.5441	(8) 40	4.6899	40.0	37.8	0.0021
37.5	1.5740	(13) 65	5.2822	65.0	61.1	0.0064
40.0	1.6021	(16) 80	5.8362	80.0	79.8	0.0000
42.5	1.6284	(18) 90	6.3566	90.0	91.2	0.0018
45.0	1.6532	(20)100	6.8473	98.7	96.2	0.0171

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

2. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Balanites aegyptiaca for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	1.5348	0.3	0.1	0.0040
5.0	0.6990	(5) 25	4.2129	25.0	21.6	0.0068
7.5	0.8751	(12) 60	5.7795	60.0	78.2	0.1943
8.0	0.9031	(18) 90	6.0289	90.0	84.8	0.0210
9.0	0.9542	(19) 95	6.4840	95.0	93.1	0.0056
10.0	1.0000	(20)100	6.8911	99.0	97.0	0.0137

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

3. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Boswellia dalzielii for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	1.9030	0.3	0.1	0.0040
10.0	1.0000	(1) 5	3.3242	5.0	4.7	0.0002
15.0	1.1761	(4) 20	4.1555	20.0	19.9	0.0000
20.0	1.3010	(7) 35	4.7454	35.0	39.9	0.0100
25.0	1.3979	(12) 60	5.2029	60.0	58.0	0.0016
30.0	1.4771	(15) 75	5.5767	75.0	71.8	0.0051
35.0	1.5441	(16) 80	5.8928	80.0	81.4	0.0013
40.0	1.6021	(20)100	6.1666	96.5	87.3	0.0707

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

4. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Detarium microcarpum for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (PPM)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
7.5	0.8751	(0) 0	3.8770	4.1	13.1	0.0711
10.0	1.0000	(6) 30	4.3381	30.0	25.4	0.0112
15.0	1.1761	(8) 40	4.9879	40.0	49.5	0.0361
20.0	1.3010	(13) 65	5.4490	65.0	67.3	0.0024
25.0	1.3979	(17) 85	5.8066	85.0	79.0	0.0217
30.0	1.4771	(17) 85	6.0988	85.0	86.4	0.0017
35.0	1.5441	(20)100	6.3459	97.1	91.1	0.0444

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

5. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Kigelia africana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
30.0	1.4771	(0) 0	3.5562	2.6	7.4	0.0336
35.0	1.5441	(4) 20	4.0942	20.0	18.3	0.0019
40.0	1.6021	(6) 30	4.5602	30.0	33.0	0.0041
45.0	1.6532	(9) 45	4.9713	45.0	48.8	0.0058
50.0	1.6990	(12) 60	5.3390	60.0	63.3	0.0047
55.0	1.7404	(16) 80	5.6716	80.0	74.9	0.0138
60.0	1.7782	(20)100	5.9753	94.8	97.6	0.0335

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

6. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extract of Parkia clappertoniana for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	2.2768	0.3	0.3	0.0000
5.0	0.6990	(4) 20	4.0593	20.0	17.4	0.0047
7.5	0.8751	(9) 45	5.1020	45.0	54.1	0.0333
8.0	0.9031	(11) 55	5.2679	55.0	60.5	0.0127
9.0	0.9542	(16) 80	5.5708	80.0	71.6	0.0347
10.0	1.0000	(20)100	5.8414	94.0	80.0	0.1225

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

7. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentration of ECW extract of Sclerocarya birrea for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm.)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.0000	(0) 0	3.3099	1.6	4.6	0.0205
12.5	1.0969	(5) 25	4.1714	25.0	20.4	0.0130
15.0	1.1761	(8) 40	4.8753	40.0	45.0	0.0101
17.5	1.2430	(13) 65	5.4705	65.0	68.1	0.0044
20.0	1.3010	(16) 80	5.9860	80.0	83.8	0.0106
22.5	1.3522	(19) 95	6.4408	95.0	92.5	0.0090
25.0	1.3979	(20)100	6.8475	98.4	96.7	0.0091

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

8. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extract of Ximenia americana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
12.5	1.0969	(0) 0	3.6691	2.9	9.2	0.0475
15.0	1.1761	(4) 20	4.1170	20.0	18.9	0.0008
20.0	1.3010	(8) 40	4.8236	40.0	43.0	0.0037
25.0	1.3979	(13) 65	5.3718	65.0	64.5	0.0001
30.0	1.4771	(16) 80	5.8196	80.0	79.4	0.0002
35.0	1.5441	(20)100	6.1983	96.5	88.5	0.0629

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

9. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of ECW extracts of Vetiveria nigritana for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.0000	(0) 0	2.3194	0.3	0.4	0.0003
12.0	1.0792	(2) 10	3.5290	10.0	7.1	0.0128
14.0	1.1461	(5) 25	4.5517	25.0	32.7	0.0269
15.0	1.1761	(8) 40	5.0094	40.0	50.3	0.0424
16.0	1.2041	(15) 75	5.4376	75.0	66.7	0.0310
18.0	1.2553	(18) 90	6.2190	90.0	88.9	0.0012
20.0	1.3010	(20)100	6.9180	99.0	97.2	0.0119

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix II contd.

10. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of $CuSO_4$ reference control molluscicide for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]

Conc. in (ppm)	log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
0.25	-0.6021	(0) 0	1.0555	0.3	0.1	0.0040
0.50	-0.3010	(2) 10	3.5531	10.0	7.4	0.0099
0.75	-0.1249	(7) 35	5.0142	35.0	50.5	0.0961
0.90	-0.0458	(15) 75	5.6711	75.0	74.9	0.0000
1.00	0.0000	(18) 90	6.0508	90.0	85.3	0.0176
2.00	0.3010	(20)100	8.5485	99.7	99.9	0.0040

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III.

1. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UDCM extract of Acacia nilotica for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	2.6921	0.3	0.3	0.0000
10.0	1.0000	(4) 20	4.0569	20.0	17.3	0.0051
15.0	1.1761	(8) 40	4.8552	40.0	44.2	0.0072
20.0	1.3010	(12) 60	5.4217	60.0	66.3	0.0178
25.0	1.3979	(17) 85	5.8610	85.0	85.0	0.0129
30.0	1.4771	(20)100	6.2200	96.5	88.9	0.0585

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

2. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UPCs extracts of Aristolochia albida for 24 hours [corrected probits, corrected effects; expected effects and deviation (GI) incorporated]

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
40.0	1.6021	(0) 0	2.8091	0.7	0.4	0.0035
45.0	1.6532	(1) 5	3.5166	5.0	6.9	0.0056
50.0	1.6990	(4) 20	4.1495	20.0	19.8	0.0000
55.0	1.7404	(10) 50	4.7226	50.0	39.1	0.0499
60.0	1.7782	(12) 60	5.2445	60.0	59.8	0.0000
70.0	1.8451	(17) 85	6.1705	85.0	87.9	0.0079
80.0	1.9031	(20)100	6.9725	99.0	97.6	0.0084

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

3. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Balanites aegyptiaca for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
1.0	0.0000	(0) 0	3.5539	2.3	7.4	0.0380
2.5	0.3979	(8) 20	4.6037	40.0	34.0	0.0129
5.0	0.6990	(12) 60	5.3979	60.0	66.4	0.0184
7.5	0.8751	(13) 65	5.8625	65.0	80.6	0.1556
8.0	0.9031	(16) 80	5.9364	80.0	82.5	0.0043
9.0	0.9542	(19) 95	6.0714	95.0	85.9	0.0684
10.0	1.0000	(20)100	6.1921	96.2	88.4	0.0593

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

4. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UBCW extracts of Blighia sapida for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (PPM)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	3.2904	1.3	4.4	0.0228
7.5	0.8751	(5) 25	4.1139	25.0	18.8	0.0252
10.0	1.0000	(8) 40	4.6982	40.0	38.1	0.0015
15.0	1.1761	(12) 60	5.5218	60.0	69.9	0.0466
20.0	1.3010	(18) 90	6.1061	90.0	86.6	0.0100
25.0	1.3979	(20)100	6.5593	98.0	94.0	0.0284

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

5. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Boswellia dalzielii /corrected probits, corrected effects, expected effects, and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
20.0	1.3010	(0) 0	3.1270	1.0	3.0	0.0137
25.0	1.3979	(3) 15	4.0042	15.0	16.0	0.0007
30.0	1.4771	(8) 40	4.7209	40.0	39.0	0.0004
35.0	1.5441	(13) 65	5.3269	65.0	62.8	0.0021
40.0	1.6021	(16) 80	5.8518	80.0	80.3	0.0001
45.0	1.6532	(18) 90	6.3148	90.0	90.6	0.0004
50.0	1,6990	(20)100	6.7290	98.4	95.2	0.0224

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

6. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UBCW extracts of Detarium microcarpum for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
1.0	0.0000	(0) 0	2.7509	0.3	0.3	0.0000
2.5	0.3979	(5) 25	4.1211	25.0	19.0	0.0234
5.0	0.6990	(9) 45	5.1576	45.0	56.3	0.0519
7.5	0.8751	(12) 60	5.7639	60.0	77.7	0.1808
8.0	0.9031	(16) 80	5.8604	80.0	80.5	0.0002
9.0	0.9542	(19) 95	6.0368	95.0	85.0	0.0784
10.0	1.0000	(20)100	6.1941	96.2	88.4	0.0593

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

7. **Number of dead adult lymnaea natalensis out of 20 exposed to different concentrations of UBC extracts of Cnidia kraussiana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
35.0	1.5441	(0) 0	3.5192	2.3	6.7	0.0310
40.0	1.6021	(3) 15	4.0845	15.0	18.0	0.0061
45.0	1.6532	(8) 40	4.5832	40.0	33.8	0.0172
50.0	1.6990	(11) 55	5.0292	55.0	51.2	0.0058
55.0	1.7404	(12) 60	5.4328	60.0	66.7	0.0202
60.0	1.7782	(16) 80	5.8011	80.0	78.8	0.0009
65.0	1.8129	(20)100	6.1400	95.9	87.3	0.0667

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

8. Number of dead adult Lymnaea natalensis out of 20 exposed different concentrations of UECW extracts of Kigelia africana for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
50.0	1.6990	(0) 0	3.2820	4.5	4.3	0.0001
60.0	1.7782	(4) 20	4.2865	20.0	23.8	0.0080
70.0	1.8451	(12) 60	5.1359	60.0	56.4	0.0053
80.0	1.9031	(16) 80	5.8716	80.0	80.8	0.0004
90.0	1.9542	(19) 95	6.5206	95.0	93.6	0.0033
100.0	2.0000	(20)100	7.1011	97.7	98.3	0.0022

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

9. Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UBCW extracts of Opilia celtidefolia for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	2.4955	0.3	0.6	0.0015
10.0	1.0000	(4) 20	4.0096	20.0	16.1	0.0113
15.0	1.1761	(8) 40	4.8954	40.0	45.8	0.0136
20.0	1.3010	(12) 60	5.5238	60.0	70.0	0.0476
25.0	1.3979	(18) 90	6.0112	90.0	84.2	0.0253
30.0	1.4771	(20)100	6.4095	97.4	92.0	0.0396

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

10. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Nauclea latifolia for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
20.0	1.3010	(0) 0	2.5917	0.3	0.8	0.0032
30.0	1.4771	(4) 20	3.9252	20.0	14.1	0.0287
40.0	1.6021	(7) 35	4.8713	35.0	44.9	0.0396
45.0	1.6532	(10) 50	5.2587	50.0	60.2	0.0434
50.0	1.6990	(14) 70	5.6052	70.0	72.8	0.0040
55.0	1.7404	(18) 90	5.9187	90.0	82.1	0.0425
60.0	1.7782	(20)100	6.2048	96.5	88.6	0.0618

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

11. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Parkia clappertoniana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
1.0	0.0000	(0) 0	3.8154	3.8	11.8	0.0615
2.5	0.3979	(8) 40	4.7024	40.0	38.3	0.0012
5.0	0.6990	(12) 60	5.3733	60.0	64.5	0.0088
7.5	0.8751	(16) 80	5.7658	80.0	77.8	0.0028
10.0	1.0000	(20)100	6.0443	95.3	85.2	0.0809

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

12. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Polygonum limnatum for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	3.0987	1.0	2.5	0.0092
10.0	1.0000	(6) 30	4.4680	30.0	36.3	0.0172
15.0	1.1761	(12) 60	5.2689	60.0	60.6	0.0002
20.0	1.3010	(16) 80	5.8372	80.0	79.9	0.0000
25.0	1.3979	(18) 90	6.2780	90.0	89.9	0.0000
30.0	1.4771	(20)100	6.6382	98.4	94.9	0.0253

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

13. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Pseudocedrela kotschyi for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
70.0	1.8451	(0) 0	3.2785	1.4	4.3	0.0204
72.5	1.8603	(2) 10	3.8487	10.0	12.5	0.0057
75.0	1.8751	(8) 40	4.3995	40.0	27.4	0.0789
80.0	1.9031	(12) 60	5.4481	60.0	67.3	0.0242
82.5	1.9165	(16) 80	5.9480	80.0	82.8	0.0055
85.0	1.9294	(19) 95	6.4331	95.0	92.4	0.0096
90.0	1.9542	(20)100	7.3618	99.7	99.9	0.0040

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

14. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Securidaca longipedunculata for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	3.1842	1.3	3.5	0.0143
10.0	1.0000	(4) 20	4.0582	20.0	17.3	0.0051
15.0	1.1761	(7) 35	4.5695	35.0	33.3	0.0013
20.0	1.3010	(8) 40	4.9322	40.0	47.3	0.0214
30.0	1.4771	(12) 60	5.4435	60.0	67.1	0.0228
40.0	1.6021	(17) 85	5.8062	85.0	79.0	0.0217
50.0	1.6990	(20)100	6.0876	95.6	86.2	0.0743

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

15. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UECW extracts of Ximenia americana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/**

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.0000	(0) 0	2.0834	0.3	0.2	0.0095
12.5	1.0969	(1) 5	3.3021	5.0	4.5	0.0006
15.0	1.1761	(4) 20	4.2978	20.0	24.1	0.0092
17.5	1.2430	(12) 60	5.1396	60.0	56.5	0.0050
20.0	1.3010	(16) 80	5.8689	80.0	80.7	0.0050
25.0	1.3979	(20)100	7.0875	99.9	98.2	0.0068

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

16. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of UBCW extracts of Vetiveria nigritana for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
35.0	1.5441	(0) 0	3.7554	6.7	10.7	0.0167
40.0	1.6021	(8) 40	4.2927	40.0	24.0	0.1404
45.0	1.6532	(8) 40	4.7667	40.0	40.8	0.0003
50.0	1.6990	(12) 60	5.1907	60.0	57.6	0.0024
55.0	1.7404	(12) 60	5.5743	60.0	71.7	0.0675
60.0	1.7782	(16) 80	5.9244	80.0	82.2	0.0033
70.0	1.8451	(20)100	6.5448	95.6	93.9	0.0050

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix III contd.

17. **Number of dead adult Lymnaea natalensis out of 20 exposed to different concentrations of $CuSO_4$ reference molluscicide for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
0.25	-0.6021	(0) 0	1.0555	0.3	0.1	0.0040
0.50	-0.3010	(2) 10	3.5531	10.0	7.4	0.0099
0.75	-0.1249	(7) 35	5.0142	35.0	50.5	0.0961
0.90	-0.0458	(15) 75	5.6711	75.0	74.9	0.0000
1.0	0.0000	(18) 90	6.0508	90.0	85.3	0.0176
2.0	0.3010	(20)100	8.5485	99.7	99.9	0.0040

*Mortality figures in parentheses are number dead out of 20 exposed while those outside parentheses are percentage dead.

Appendix IV

1. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Balanites aegyptiaca for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
4.0	0.6021	(0) 0	2.0042	0.4	0.2	0.0020
5.0	0.6990	(0) 0	3.0664	1.3	2.7	0.0075
6.0	0.7782	(1) 10	3.9344	20.0	14.3	0.0265
7.0	0.8451	(3) 30	4.6682	30.0	37.0	0.0210
8.0	0.9031	(5) 50	5.3038	50.0	61.9	0.0600
9.0	0.9542	(8) 80	5.8645	80.0	80.6	0.0002
10.0	1.0000	(10)100	6.3661	95.6	91.4	0.0224

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

2. **Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Blighia sapida for 24 hours /corrected probits, corrected effects, expected effects, and deviation (GI) incorporated/**

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
20.0	1.3010	(0) 0	0.0010	0.1	0.1	0.0000
30.0	1.4771	(0) 0	1.9941	0.2	1.2	0.0084
40.0	1.6021	(1) 10	3.4083	10.0	13.2	0.0089
50.0	1.6990	(2) 20	4.5052	20.0	40.7	0.1775
60.0	1.7782	(5) 50	5.4014	50.0	68.6	0.1616
70.0	1.8451	(9) 90	6.1592	90.0	86.3	0.0116
80.0	1.9031	(10)100	6.8155	98.0	94.7	0.0217
90.0	1.9542	(10)100	7.3945	99.3	98.1	0.0077

*Mortality figures in parentheses are number dead of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

3. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extracts of Boswellia dalzielii for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
30.0	1.4771	(0) 0	1.2045	0.1	0.1	0.0000
40.0	1.6021	(0) 0	2.7258	0.3	1.2	0.0068
50.0	1.6990	(1) 10	3.9058	10.0	12.7	0.0066
60.0	1.7782	(2) 20	4.8699	20.0	44.8	0.2487
70.0	1.8451	(8) 80	5.6850	80.0	80.0	0.0000
80.0	1.9031	(9) 90	6.3911	90.0	91.6	0.0043
90.0	1.9542	(10)100	7.0139	99.3	99.3	0.0000
100.0	2.0000	(10)100	7.5711	99.6	99.5	0.0002

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

4. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extracts of Cissampelos mucronata for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	1.5769	0.3	0.1	0.0040
10.0	1.0000	(0) 0	2.7495	0.3	1.2	0.0068
20.0	1.3010	(1) 10	3.9221	10.0	14.1	0.0139
30.0	1.4771	(2) 20	4.6080	20.0	34.8	0.0965
40.0	1.6021	(4) 40	5.0947	40.0	53.8	0.0766
50.0	1.6990	(6) 60	5.4722	60.0	68.2	0.0310
60.0	1.7782	(10)100	5.7806	67.8	78.3	0.0649
70.0	1.8451	(10)100	6.0414	76.5	85.1	0.0589

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

5. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Detarium microcarpum for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]

Conc. in (ppm)	log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
1.0	0.0000	(0) 0	2.6700	2.0	1.1	0.0074
2.0	0.3010	(0) 20	4.3608	20.0	26.2	0.0199
3.0	0.4771	(5) 50	5.3498	50.0	63.7	0.0812
4.0	0.6021	(8) 80	6.0515	80.0	85.4	0.0234
5.0	0.6990	(10)100	6.5958	97.1	94.5	0.0130
6.0	0.7792	(10)100	7.0405	98.1	97.9	0.0002

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

6. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Kigelia africana for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	2.3775	0.3	0.5	0.0008
5.0	0.6990	((1) 10	3.6585	10.0	9.0	0.0012
10.0	1.0000	(6) 60	4.9395	60.0	47.6	0.0616
20.0	1.3010	(8) 80	6.2205	80.0	88.9	0.0803
30.0	1.4771	(10)100	6.9698	94.7	97.5	0.0322
40.0	1.6021	(10)100	7.5015	98.3	99.4	0.0203

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

7. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Mauclea latifolia for 24 hours /corrected probits, corrected effects, expected effects and deviation (GI) incorporated/

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Frobit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	2.2660	1.0	0.3	0.0164
5.0	0.6990	(1) 10	3.5037	10.0	6.7	0.0174
10.0	1.0000	(3) 30	4.7413	30.0	39.8	0.0401
20.0	1.3010	(5) 50	5.9700	80.0	83.6	0.0095
30.0	1.4771	(8) 80	6.7030	91.3	95.6	0.0440
40.0	1.6021	(10)100	7.2167	96.4	98.7	0.0412

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

8. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extracts of Opilia celtidefolia for 24 hours [corrected probits, corrected effects, expected effects and deviation (GI) incorporated]

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Effect	Corrected Effect	Expected Effect	Deviation (GI)
5.0	0.6990	(0) 0	2.8708	1.3	1.7	0.0010
6.0	0.7782	(2) 20	3.9461	20.0	14.6	0.0234
7.0	0.8451	(5) 50	4.8553	50.0	44.3	0.0132
8.0	0.9031	(6) 60	5.6428	60.0	74.0	0.1019
9.0	0.9542	(9) 90	6.3375	90.0	90.9	0.0010
10.0	1.0000	(10)100	6.9589	98.4	97.5	0.0033

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

9. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extracts of Parkia clappertoniana for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated).

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
0.18	-0.7447	(0) 0	3.8709	7.6	12.9	0.0250
0.25	-0.6021	(4) 40	4.2664	40.0	23.2	0.1584
0.50	-0.3010	(5) 50	5.1009	50.0	54.0	0.0064
0.75	-0.1249	(7) 70	5.5890	70.0	72.2	0.0024
1.00	0.0000	(9) 90	5.9354	90.0	82.5	0.0390
2.00	0.3010	(10)100	6.7699	96.8	96.1	0.0013

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

10. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Polygonum limnatum for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.0000	(0) 0	2.0165	0.2	0.1	0.0010
20.0	1.3010	(0) 0	3.2566	1.3	2.8	0.0083
30.0	1.4771	(2) 20	3.9820	20.0	14.6	0.0234
40.0	1.6021	(2) 20	4.4967	20.0	32.9	0.0754
50.0	1.6990	(5) 50	4.8959	50.0	51.5	0.0009
60.0	1.7782	(6) 60	5.2221	60.0	66.4	0.0184
70.0	1.8451	(7) 70	5.4979	70.0	77.4	0.0313
80.0	1.9031	(10)100	5.7367	93.3	85.0	0.0540
90.0	1.9542	(10)100	5.9475	94.8	90.1	0.0248

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

11. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Pseudocedrela kotschyi for 24 hours [corrected probits, corrected effects, expected effects, and deviation (GI) incorporated]

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
2.5	0.3979	(0) 0	2.7985	1.3	1.4	0.0001
5.0	0.6990	(0) 0	3.3733	2.9	5.2	0.0107
10.0	1.0000	(3) 30	3.9482	30.0	14.7	0.1867
20.0	1.3010	(3) 30	4.5231	30.0	31.7	0.0013
30.0	1.4771	(5) 50	4.8594	50.0	44.4	0.0127
40.0	1.6021	(5) 50	5.0980	50.0	53.9	0.0061
50.0	1.6990	(5) 50	5.2830	50.0	61.2	0.0528
60.0	1.7782	(6) 60	5.4342	60.0	66.8	0.0208
70.0	1.8451	(7) 70	5.5621	70.0	71.3	0.6008
80.0	1.9031	(7) 70	5.6728	70.0	74.9	0.0128
90.0	1.9542	(8) 80	5.7705	80.0	78.0	0.0023
100.0	2.0000	(9) 90	5.8579	90.0	80.4	0.0585
110.0	2.0414	(10)100	5.9369	95.6	82.5	0.1189

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

12. Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of UECW extract of Securidaca longipedunculata for 24 hours (corrected probits, corrected effects, expected effects and deviation (GI) incorporated)

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
10.0	1.0000	(0) 0	1.1965	0.3	0.1	0.0040
20.0	1.3010	(0) 0	3.2009	0.3	3.6	0.0314
30.0	1.4771	(1) 10	4.3735	10.0	26.5	0.0270
40.0	1.6021	(5) 50	5.2054	50.0	58.1	0.0270
50.0	1.6990	(7) 70	5.8507	70.0	80.3	0.0671
60.0	1.7780	(9) 90	6.3779	90.0	91.6	0.0033
70.0	1.8451	(10)100	6.8237	99.3	96.6	0.0222
80.0	1.9031	(10)100	7.2098	99.7	98.7	0.0078

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.

Appendix IV contd.

13, Number of dead young Lymnaea natalensis out of 10 exposed to different concentrations of $CuSO_4$ reference molluscicide for 24 hours [corrected probits, corrected effects, expected effects, and deviation a(GI) incorporated]

Conc. in (ppm)	Log. Conc.	Mortality *	Corrected Probit	Corrected Effect	Expected Effect	Deviation (GI)
0.09	-0.0458	(0) 0	5.6457	89.6	74.1	0.1252
0.18	-0.7447	(7) 70	6.0213	70.0	84.6	0.1636
0.25	-0.6021	(8) 80	6.1994	80.0	88.5	0.0710
0.50	-0.3010	(9) 90	6.5749	90.0	94.2	0.0323
0.75	-0.1249	(10)100	6.7947	98.0	96.4	0.0074
1.00	0.0000	(10)100	6.9505	98.7	97.5	0.0059

*Mortality figures in parentheses are number dead out of 10 exposed while those outside parentheses are percentage dead.