PN-AAZ-812
56022 5.180

15 February 1988

PROGRESS REPORT

BIOLOGICAL CONTROL OF SNAIL BORNE PARASITES IN KENYA

(September 1987 - February 1988)

by Eric S. Loker

This report is based in part on information gathered during my third trip to Kenya (27 Dec 87 - 18 Jan 88) as part of the project. This report is divided into sections, each of which describes a separate phase of the project.

1. Laboratory Studies on Putative Biological Control Species

We are interested to learn if native African ampullariid snails in the genera Pila and Lanistes are able to consume egg masses and juveniles of snails involved in transmission of schistosomiasis. Our interest is motivated by the fact that the South American ampullariid Marisa cornuarietis, which is a known predator of eggs and juveniles, has already been introduced into African waters as a biological control agent. We believe that further study of native African species should be undertaken before Marisa is introduced in other locations, specifically Kenya.

In the two previous progress reports, we have documented in laboratory studies that the ampullariids Lanistes carinatus and Pila ovata from Kenya will consume egg masses and juveniles of Biomphalaria at rates comparable to those exhibited by the South American ampullariid Marisa cornuarietis. Since filing those reports, we have also established Lanistes ovum ovum in the laboratory, and have learned that this species does not readily consume Biomphalaria eggs and juveniles.

We have initiated further laboratory studies on the predatory habits of native Kenyan ampullariids. Ampullariids are relatively large and heavy, and we suspect that they are less able to glide freely at the water's surface than the smaller pulmonates. Free-floating objects could serve as refugia for schistosome snail hosts if ampullariids are unable to reach them. We have tested the ability of ampullariids to reach floating pieces of styrofoam on which Biomphalaria egg masses have been deposited. The styrofoam floats were held away from all fixed surfaces, such that the ampullariids would have to detach from the walls of the aquarium and "skate" 5 cm across the water's surface to reach the eggs. This experiment was attempted with P. ovata, L. carinatus, L. ovum, Marisa, and Biomphalaria glabrata. For each of 6 replicates, 2 adult snails of a particular species were placed in an aquarium containing such a styrofoam float. No other sources of food were present. The number of egg masses consumed during a two day interval was determined. An additional six replicates were performed in aquaria that contained lettuce as a supplemental food.

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For either experimental protocol, we discovered that the great majority of Biomphalaria egg masses were not disturbed, regardless of the snail species tested, suggesting that floating objects may well serve as refugia in natural habitats. The potential importance of this result is highlighted by field observations of Bulinus egg masses attached to free-floating pieces of vegetation. Also, other locations, such as cracks in rocks, may prevent access of large-bodied ampullariids and serve as refugia for target pulmonate species. Probably most freshwater habitats contain some microhabitats that are not freely accessible to ampullariids; consequently, complete elimination of target molluscs is probably not a reasonable expectation. However, a significant degree of control or perhaps even cessation of transmission of schistosomiasis does not necessarily depend on complete elimination of the snail hosts.

Additional laboratory studies are underway to determine if juveniles of Pila and Lanistes are capable of preying upon Biomphalaria egg masses and juveniles.

2. Field Studies at Regular Study Sites

As mentioned in previous reports, four study sites have been established in the Kitui area of Kenya. Each habitat has a total of six different sampling locations. Once each month, snails are collected at each sampling location and enumerated; this enables us to monitor general patterns of snail abundance in these habitats. Also, we have had the water at each location analyzed chemically by the Kenyan Government Chemist's Department. It has been necessary to abandon one of these sites (Mwea East Pond) because we discovered that it had been inadvertantly contaminated by molluscicidal chemicals. Water from the three remaining locations (Matingani Seepage Area, Mbondoni Dam, and Kangonde Dam) is consumed by local people and their domestic animals, but is not used for irrigation of crops.

During my recent visit to Kenya, we traveled to the Malindi area and collected approximately 1800 Lanistes carinatus snails from three different locations; they were then transported to our study sites. For each of these three sites, 100 L. carinatus snails were added to each of the six sampling locations. The decision to use L. carinatus rather than other native ampullariids was based mostly on considerations of availability; we were sure we could find enough individuals of this species to make the introductions a feasible proposition. The fate of the introduced Lanistes will now be monitored monthly along with the snails naturally present in each location.

The experiment will enable us to learn if L. carinatus can establish self-perpetuating colonies in up-country locations approximately 200 km removed from its center of distribution in coastal Kenya. This in itself will be informative for it will help to delimit factors that control ampullariid distribution in Kenya. For example, it is conceivable that dispersal of ampullariids is severely limited by their large body size, their dioecious breeding systems, and by the relatively large size of their progeny. Alternatively, the relatively cooler and dryer climate of up-country locations may preclude establishment of such snails. We have also placed L. carinatus in small concrete-lined pools on the grounds of the Division of Vector-Borne Diseases (DVBD) in Nairobi. The ability of these snails to establish self-sustaining colonies in the relatively cool climate of Nairobi is also being systematically monitored by DVBD personnel associated with this project.

By monitoring populations of Biomphalaria pfeifferi, Bulinus tropicus, Lymnaea natalensis, and Melanoides tuberculata found in the various study sites, and by comparing trends before and after introduction of L. carinatus, we also hope to gain information regarding the potential ability of this snail to displace other snail species.

3. Survey of Snail Habitats of Kenya

We have continued to collect freshwater snails in various regions of Kenya as part of our effort to become better acquainted with the natural distributions of all freshwater snails in the country. This aspect of the project will allow us to determine if particular pairs of species occur together more or less often than would be expected by chance. As previously mentioned, it will help to determine if some measure of natural biological control of schistosomiasis is taking place. Such trips have also enabled us to gain collections of living and preserved snails which are studied further in my laboratory in the U.S. Furthermore, information accumulating from the survey can ultimately be used to understand the factors that control the geographic distributions of individual snail species, and as a necessary corollary, distribution of snail-transmitted disease in Kenya.

As of the date of the last progress report, we had collected snails from approximately 70 different natural habitats in Kenya. Previous reports describe the general location of such habitats and the appendix attached to this report provides the location, species found, and other relevant details for these collection sites. Since that time, we have found snails in an additional 60 habitats. The new collection localities are found in the following general regions of Kenya: areas to the east, north and west of Mt. Kenya, areas around Voi and Tsavo National Park, upper stretches of the Tana River, areas around Hola and Lamu, and additional areas south of Mombasa. These locations were specifically chosen to further define the western extent of the distribution of characteristic coastal species, and the eastern extent of the ranges of up-country species. The maps included as part of this report provide an overview of our collection activities, and also reveal several distinct and interesting patterns of distribution.

One of the most striking patterns to emerge from this study is that prosobranch snails (particularly large or relatively thick-shelled representatives such as the ampullariids and Cleopatra) predominate in coastal localities, whereas relatively thin-shelled pulmonate species predominate in locations approximately 200 km or more from the coast. In searching for possible explanations to account for this pattern, we have noted that freshwater crabs are very abundant in most snail habitats within 200 km of the coast. In contrast, crabs are rarely encountered in habitats situated further than this from the coast. Living crabs (probably the genus Potamon) have been brought to the laboratory, and have been shown to consume living Biomphalaria and Bulinus snails. Further details of these studies will be presented in a future progress report, but our preliminary studies suggest that crabs could play a major role in shaping general patterns of freshwater snail distribution in Kenya. Further study of Kenyan freshwater crabs is warranted as their taxonomy and geographic distributions are poorly known. Additionally, during the next six months, additional sites will be surveyed in the Garissa area. Although

situated approximately 500 km from the coast, it is predicted that both prosobranch snails and crabs will be found to be abundant in this particular region because of its relatively low altitude and very warm climate. Finally, high-altitude areas immediately to the east of Voi will be searched to learn if Biomphalaria can be found there.

4. Laboratory Studies on Field-Collected Kenyan Snails

Ampullariids collected and preserved as part of the above survey have been further studied in my laboratory in the U.S. to determine dietary preferences, sex ratios, and parasite burdens. Approximately 300 ampullariids, representing five different species or subspecies, and collected from 23 different habitats have been examined. The laboratory work, which has been largely undertaken by one of my students, Mr. Bruce Hofkin, is nearing completion, and a manuscript should be forthcoming in 1988.

Also, during my first trip to Kenya in early 1987, I preserved in liquid nitrogen representatives from several different populations of Biomphalaria pfeifferi and B. sudanica. Another student, Ms. Susan Bandoni, working in collaboration with Dr. Margaret Mulvey of the Savannah River Ecology Laboratory, has recently subjected these frozen snails to isozyme analysis, and will soon be preparing a manuscript on her findings.

5. Statement about Collaborative Arrangements and Personnel

As stated in earlier reports, I am pleased with the collaborative arrangements that have been made with the Kenya Medical Research Institute and the Division of Vector Borne Disease. Both organizations have participated effectively, and have given me every assurance that they will continue to do so. The persons specified in my last report, with the exception of Mr. Thiongo who is currently in the United Kingdom, continue to be actively involved in the project. During each of my trips to Kenya, I have visited the local AID Mission and have reported the project activities to them. I have indicated to them that I am very pleased with the collaborative arrangements. Consequently, no changes are anticipated in the working partnership we have established.

Mr. Hofkin, whom I have mentioned above, is very much interested in continuing to work on the project, and has expressed a strong interest in working in the field in Kenya. I have already consulted my main colleagues in Kenya (Dr. Davy Koech at KEMRI and Dr. John Ouma at DVBD) about this possibility and they have agreed in principle to this idea. Included below is a statement prepared by Mr. Hofkin that outlines his proposed activities if he is given permission to spend one year in Kenya, and if supplemental funds can be secured. It is clear that his proposed work will help to extend and amplify the exciting discoveries we have already made. Furthermore, his proposed work will not conflict with ongoing projects, nor will it prevent my Kenyan colleagues from receiving credit for their projects. Finally, it will help to provide continuity to the project in times when I can not be in Kenya. Dr. Koech has indicated that it is likely that housing will be available for Mr. Hofkin at KEMRI by the summer of 1988. Some funds for travel and support of Mr. Hofkin can be made available from my existing grant. A modest request for additional support to support his work will be made to the PSTC program.

FORM 1035
7 GAO 5000
1035-108

PUBLIC VOUCHER FOR PURCHASES & SERVICES OTHER THAN PERSONAL
CONTINUATION SHEET

VOUCHER # 6
SCHEDULE NO.
SHEET # 2

U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT
FM/PAFD ROOM 621, SA-12
WASHINGTON, D. C. 20523

THE UNIVERSITY OF N.M.
CONTRACT AND GRANT ACCOUNTING
SCHOLES HALL, RM. 205
ALBUQUERQUE, NEW MEXICO 87131

DPE-5542-G-SS-6018-00
200-140-100 FOR 281-657-100
For the period of 11/01/87 - 11/30/87

FUNDED:	$138,315.00
UNFUNDED:	$0.00
TOTAL:	$138,315.00

Major Cost Elements:	Amount For Current Period Billed	Cumulative Amt. From Incentive To Date Of This Billing.
S/W FACULTY	$0.00	$2,936.87
S/W STUDENT TEMPORARY	$0.00	$1,806.00
MATERIALS & SERVICES	$156.00	$1,836.62
EQUIPMENT	$0.00	$14,922.20
TRAVEL	$1,650.00	$1,850.00
TRAVEL-FOREIGN	$0.00	$7,273.35
FRINGE BENEFITS	$0.00	$458.95
SUBCONTRACT-	$4,792.25	$28,134.50
INDIRECT COSTS 34% MTDC	$614.04	$5,495.01
TOTAL CUMULATIVE COSTS		$64,713.50
TOTAL AMOUNT DUE	$7,212.29	

Cumulative Costs Represent
46.79% of the Funded Amount

I certify that all expenditures reported are for appropriate purposes and in accordance with the agreements set forth in the application and award documents.

Julie Albrecht

CONTRACT AND GRANT ACCOUNTING

7 GAO 3 00
1034—114

PUBLIC VOUCHER FOR PURCHASES AND SERVICES OTHER THAN PERSONAL

VOUCHER NO. 6

U.S. DEPARTMENT, BUREAU, OR ESTABLISHMENT AND LOCATION
U.S. Agency For International Development
FM/PAFD Room 621, SA-12
Washington, D. C. 20523

DATE VOUCHER PREPARED: January 13, 1988

CONTRACT NUMBER AND DATE: DPE-5542-G-SS-6018-00

REQUISITION NUMBER AND DATE:

SCHEDULE NO.

PAID BY

PAYEE'S NAME AND ADDRESS:
The University of New Mexico
Office of the Comptroller
Contract and Grant Accounting
Scholes Hall, Rm. 205
Albuquerque, NM 87131

DATE INVOICE RECEIVED

DISCOUNT TERMS

PAYEE'S ACCOUNT NUMBER: 200-140-100 For 281-657-100

SHIPPED FROM TO WEIGHT

GOVERNMENT B/L NUMBER

NUMBER AND DATE OF ORDER	DATE OF DELIVERY OR SERVICE	ARTICLES OR SERVICES (Enter description, item number of contract or Federal supply schedule, and other information deemed necessary)	QUANTITY	UNIT PRICE COST	UNIT PRICE PER	AMOUNT (1)
November 1, 1987 November 30, 1987		For detail see SF 1035 continuation sheet, total amount claimed transferred from page 2, SF 1035. Letter of Credit #DPE-5542-G-SS-6018-00 Do Not Pay This Voucher				$7,212.29

(Use continuation sheet(s) if necessary)

(Payee must NOT use the space below)

TOTAL $7,212.29

PAYMENT:
- [ ] COMPLETE
- [x] PARTIAL
- [ ] FINAL
- [ ] PROGRESS
- [ ] ADVANCE

APPROVED FOR = $

EXCHANGE RATE = $1.00

DIFFERENCES

BY[2]

TITLE

Amount verified; correct for

(Signature or initials)

Pursuant to authority vested in me, I certify that this voucher is correct and proper for payment.

(Date) (Authorized Certifying Officer)[2] (Title)

ACCOUNTING CLASSIFICATION

PAID BY

CHECK NUMBER ON TREASURER OF THE UNITED STATES

CHECK NUMBER ON (Name of bank)

CASH $ DATE

PAYEE[3]

PER

TITLE

1 When stated in foreign currency, insert name of currency.
2 If the ability to certify and authority to approve are combined in one person, one signature only is necessary; otherwise the approving officer will sign in the space provided, over his official title.
3 When a voucher is receipted in the name of a company or corporation, the name of the person writing the company or corporate name, as well as the capacity in which he signs, must appear. For example: "John Doe Company, per John Smith, Secretary", or "Treasurer", as the case may be.

BIOLOGICAL CONTROL OF SNAIL-BORNE PARASITES IN KENYA

REQUEST FOR PERMISSION TO INCLUDE MR. BRUCE HOFKIN IN PROJECT

DECEMBER 1987

The AID-funded Kenyan project now enters its second year. In the course of data analysis and observations made to date, a number of new and intriguing avenues of potential research have presented themselves. Several of these questions merit close attention, and could ultimately provide the rationale for requesting additional funding in the future. However, our ongoing projects have already placed a heavy demand on available manpower. To avoid spreading our resources too thin, it is suggested that Mr. Bruce Hofkin, a Ph.D. student in Dr. Loker's laboratory at the University of New Mexico, be assigned to further investigate some of these new discoveries. Mr. Hofkin would be concerned with projects that do not overlap or directly compete with existing projects. However, it would be mutually beneficial for all involved if Mr. Hofkin could assist with such projects as time and resources allowed. Dr. Loker will attempt to secure from AID additional funds so that Mr. Hofkin can live in Kenya for at least one year. The understanding is that projects outlined below would constitute part of his Ph.D. dissertation research. It is understood that publications resulting from his work would acknowledge the contribution of deserving Kenyan colleagues by including them as co-authors. This request is made with the realization that there is a great deal of research to be done on snails and biological control of schistosomiasis in Kenya. As stated before, we sincerely hope that Kenyan Ph.D. students will become directly involved as well.

Eastern Kenya is home to several species of indigenous freshwater crabs of the genus Potamon. Very little is known about these animals but initial observations suggest that where crabs are abundant, Biomphalaria and Bulinus may be absent or relatively rare. This raises the possibility that the crabs are excluding the snails and that these crabs may have potential as future biological control agents against molluscan vectors of schistosomiasis.

The use of crabs in gastropod control has been considered by others (Lagrange & Fain, 1952; Deschiens et. al, 1955) but we believe that this possibility needs to be further explored, especially in a Kenyan context. Since so little is known about these crabs, we propose to begin by making detailed collections and species identifications. In conjunction with this analysis of species composition and range, laboratory experiments will be performed to assess the dietary preferences of these animals, as well as their ability to consume the eggs, juveniles, and adults of Biomphalaria and Bulinus. Further studies will be conducted on the crab growth rate and on possible abiotic limits to their distribution. Additionally, although Paragonimus is not known to exist in East Africa, crabs will be checked for the larval stages of this and other potentially important human or animal parasites.

At the same time, we would like to expand our work with the African ampullariids Pila and Lanistes. We are interested in ascertaining the specific environmental factors accounting for the observed distributions. As a first step toward this end, we propose to make detailed measurements of such variables as temperature, both within and outside the geographic ranges of these snails. Other abiotic factors to be assessed include altitude, water flow rate and calcium content, and habitat permanence. The resistance to drying of ampullariids will be examined in the lab and compared with field-measured values of relative humidity in various habitats.

Perhaps the most interesting question that we wish to investigate is the possibility of using freshwater crabs and ampullariids in tandem to control Biomphalaria and Bulinus. Covich (1981) reports that freshwater habitats provide "chemical refugia" for snails, where low dissolved oxygen and high hydrogen sulfide concentrations exclude many predators, including crustaceans. This has obvious importance in any attempt to use crabs for snail control. However, a two-pronged attack, utilizing both crabs and ampullariid snails may minimize or negate this problem.

Furthermore, using two potential predators may provide for more complete control even in the absence of refuges. Most studies on the predation of crustaceans on snails (e.g. Vermeij & Covich, 1978) suggest that these predators are feeding on adult or juvenile molluscs. Our early results, on the other hand, point to egg masses as the most vulnerable stage in the Biomphalaria life cycle to predation by Pila or Lanistes. Therefore, it is possible that Biomphalaria and Bulinus populations could be reduced to more acceptable levels by increasing predation pressure on not one but two stages of the vector life cycle.

We would like to investigate both the effects of refuges on crab predation, as well as the interactions between ampullariids, crabs, and vector species in the lab. If it turns out that the combined effect of crab and ampullariid predation is greater than any individual effect, and if their habitat requirements overlap to a significant degree, we envision future work that might involve field manipulations employing these two very different types of predators.

It is to investigate questions of this nature that we wish to station Mr. Hofkin in Kenya for the year beginning in June 1988. We believe that for a relatively small investment the entire project would take on several interesting new dimensions as well as increase in scope to the point where the transmission of schistosomiasis in East Africa, as well as the biology of those organisms that might play a role in the eventual control of this disease, would be better understood.

LITERATURE CITED

Covich, A.P. 1981. Chemical refugia from predation for thin-shelled gastropods in a sulfide-enriched stream. Verh. Internat. Verein. Limnol. 21: 1632-1636.

Deschiens, R., M. Dechance, and C. Vermeil. 1955. Action predatrice des crabs d'eau douce du genre Potamon sur les mollusques des bilharzioses. Bull. Soc. Pat. Exot. 48: 203-207.

Lagrange, E. & A. Fain. 1952. Sur un nouveau predateur des mollusques pulmones d'eau douce transmetteurs de la bilharziose. Ann. Soc. Belge. Med. Trop. 32: 53-55.

Vermeij, G.J. & A.P. Covich. 1978. Coevolution of freshwater gastropods and their predators. Am. Nat. 112: 833-843.

SURVEY OF FRESHWATER GASTROPODS IN KENYA

PRELIMINARY ANALYSIS

FEBRUARY 1988

For Details Consult:

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As of 18 January 1988, freshwater snails have been found in 131 different habitats in Kenya. The data summarized on the following maps are derived from these localities. Also, more specific information for the first 74 localities is listed on the attached tables.

To help interpret the summary sheets, the following key should be consulted:

Province Number

1 = Coast
2 = Eastern
3 = Northeeastern
4 = Central
5 = Nairobi
6 = Rift Valley
7 = Nyanza

District Number

to be determined by looking at more detailed maps

Habitat Type - original classification, presently on sheets

1 = permanent stream
2 = intermittent stream
3 = pond
4 = swamp
5 = irrigation canal
6 = drainage ditch
7 = dam
8 = seepage area
9 = ox-bow lake
10 = large lake
11 = artificial habitat
12 = rice field

Alternative Habitat Classification (preferred at present, but not presently shown on summary sheets)

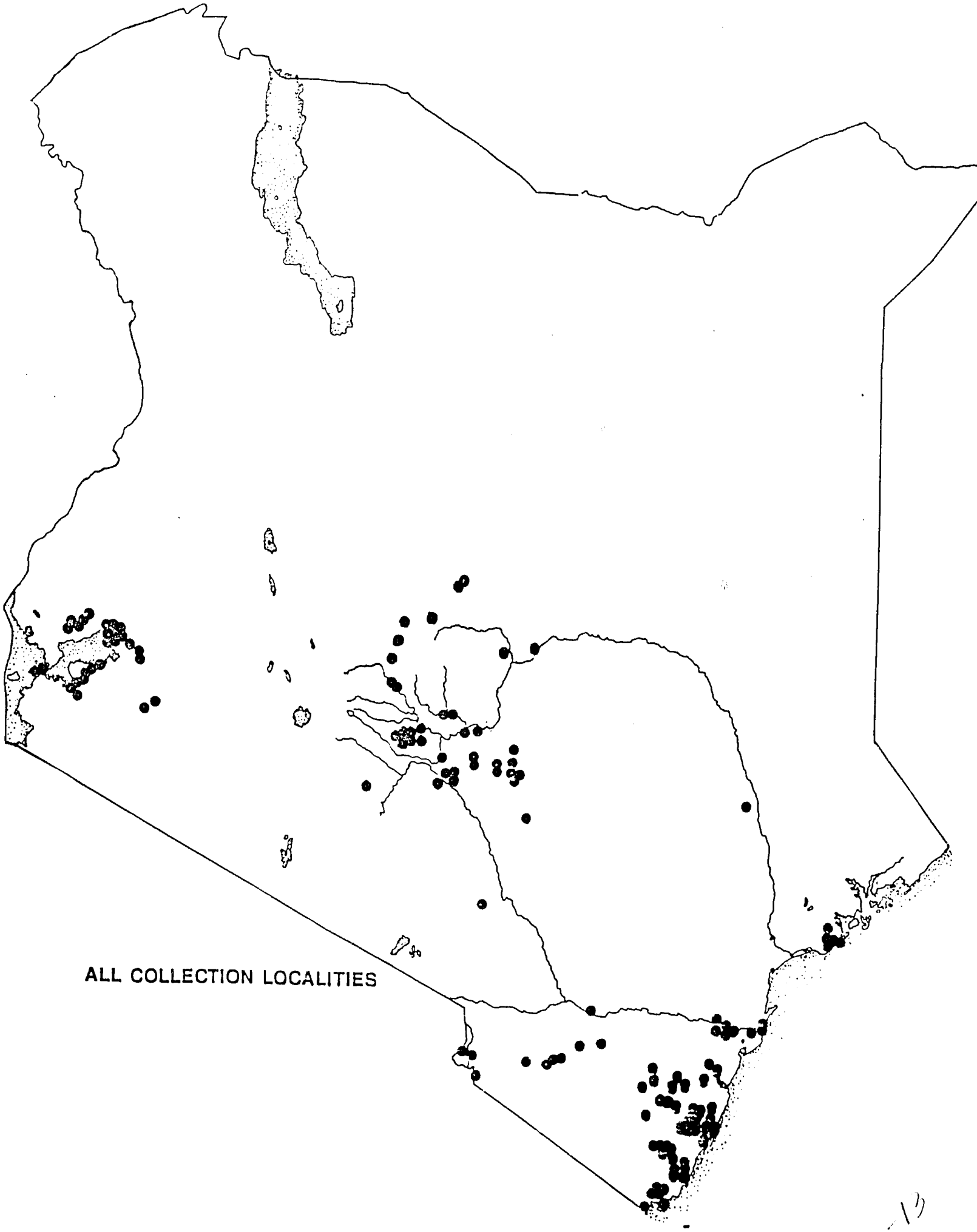
1 = large permanent streams
2 = small intermittent streams, ditches and canals (flowing)
3 = residual pools in streams (not flowing)
4 = small impoundments (dams, swamps, ponds, ow-bows)
5 = rice fields and shallow, ephemeral impoundments
6 = large permanent impoundments
7 = artificial habitats

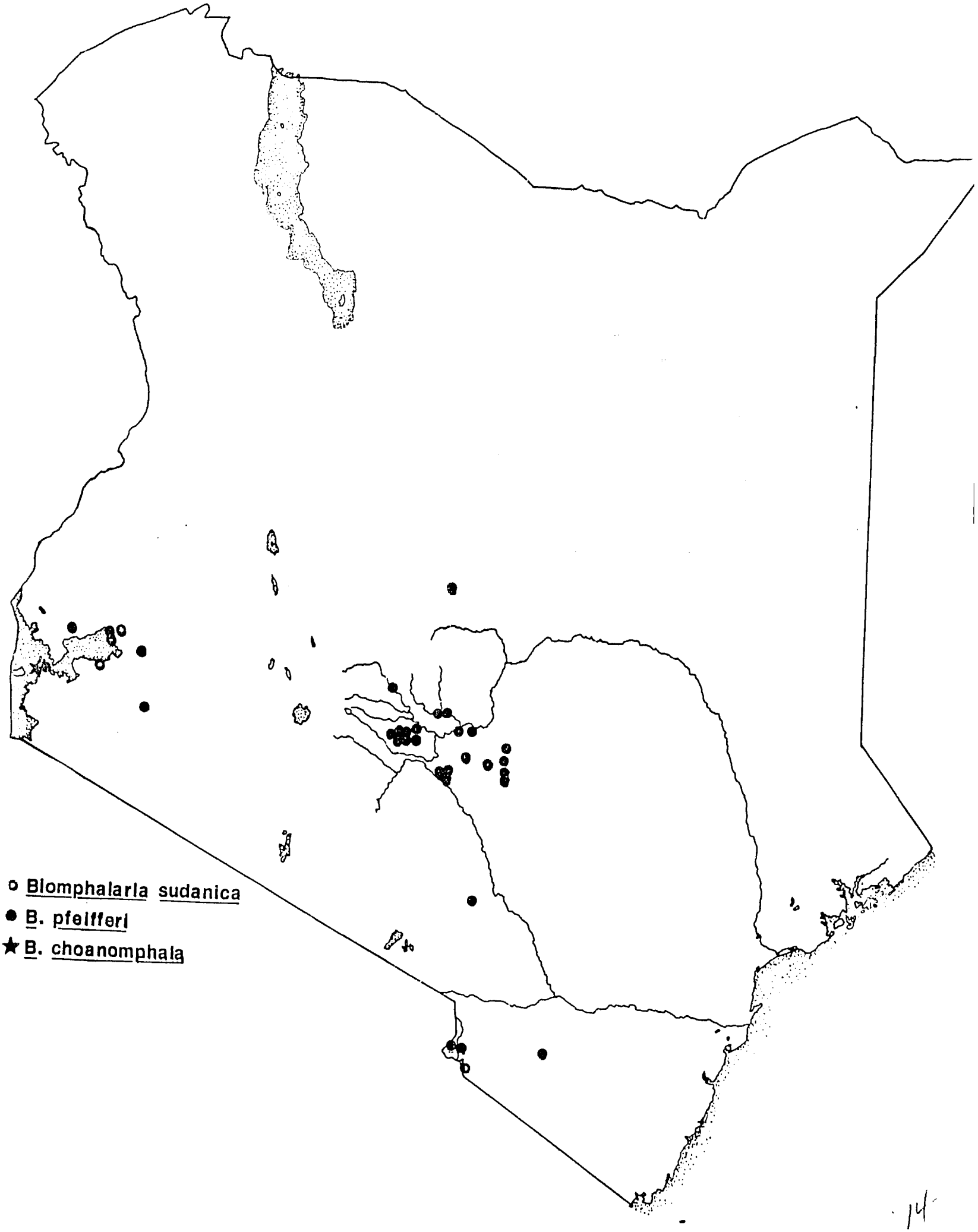
Month

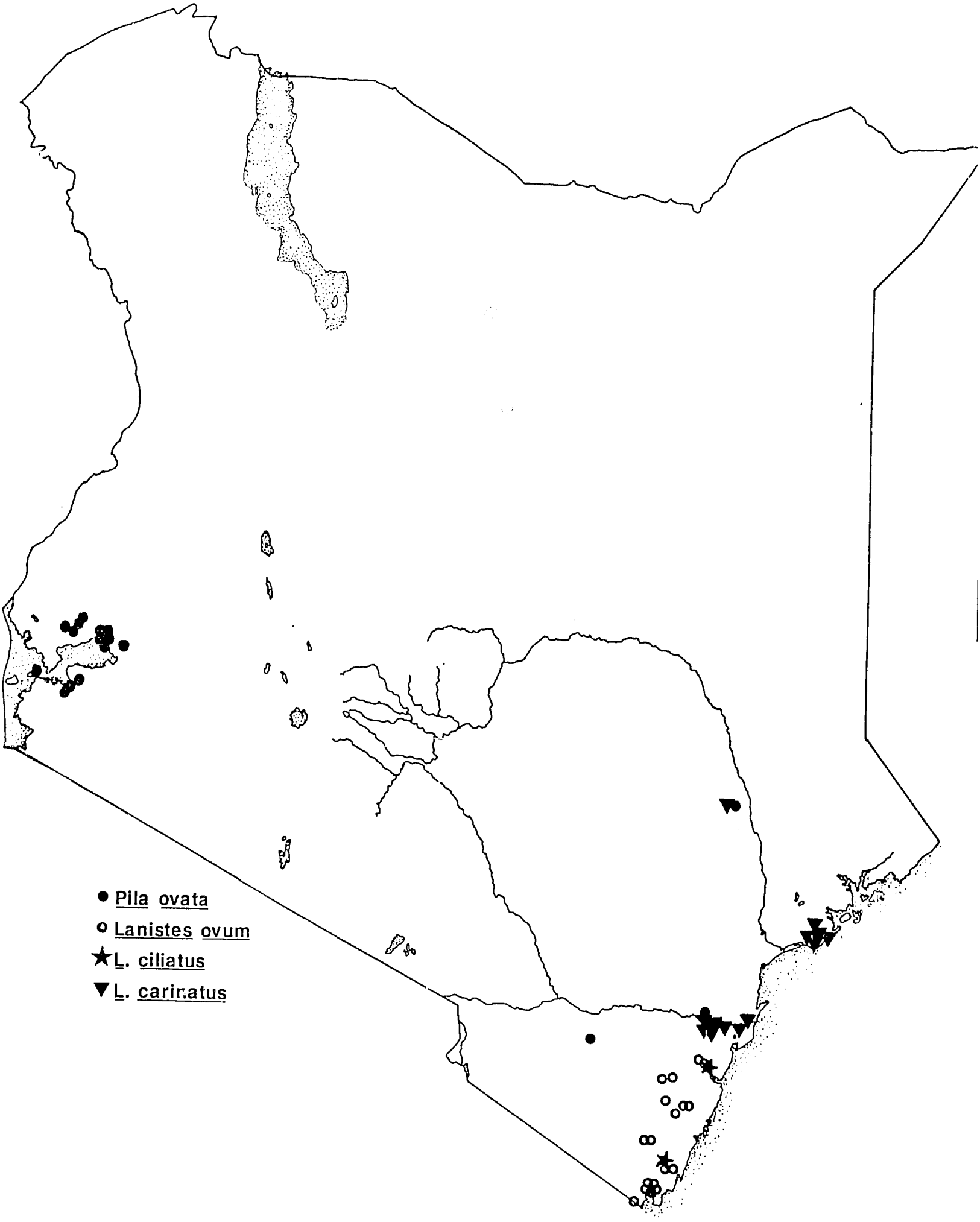
1 = January
2 = February, etc.

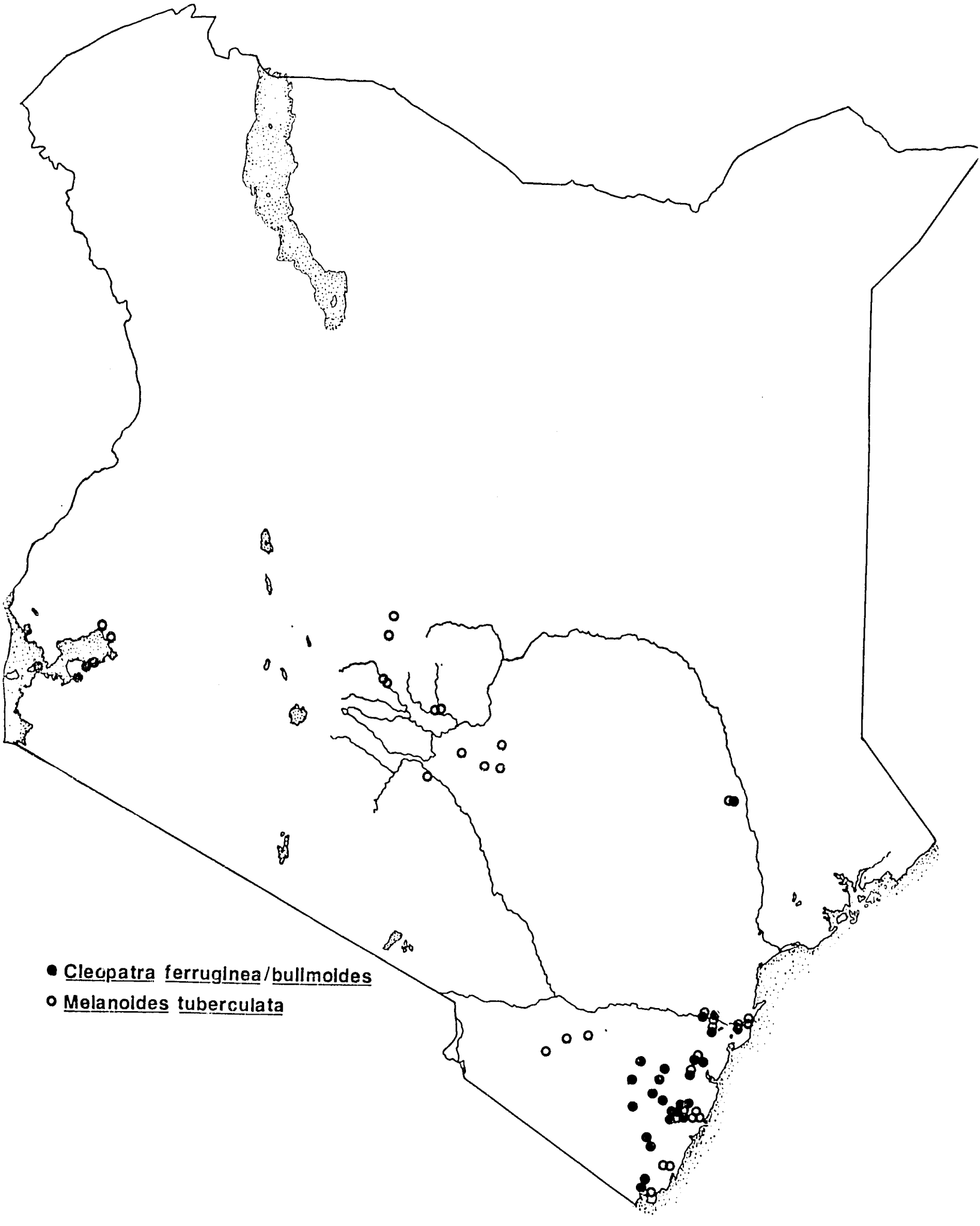
Year

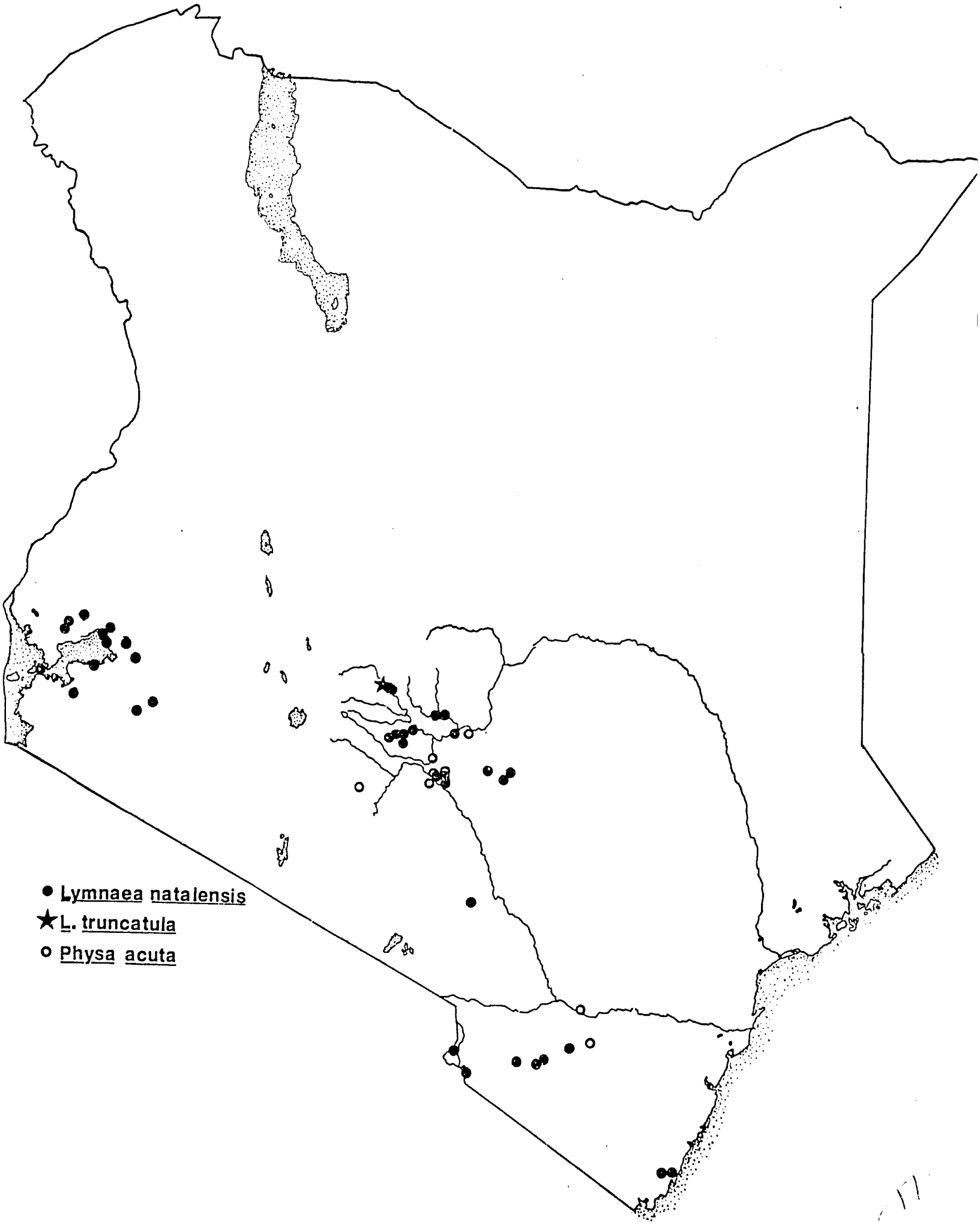
1 = 1987
2 = 1988, etc.

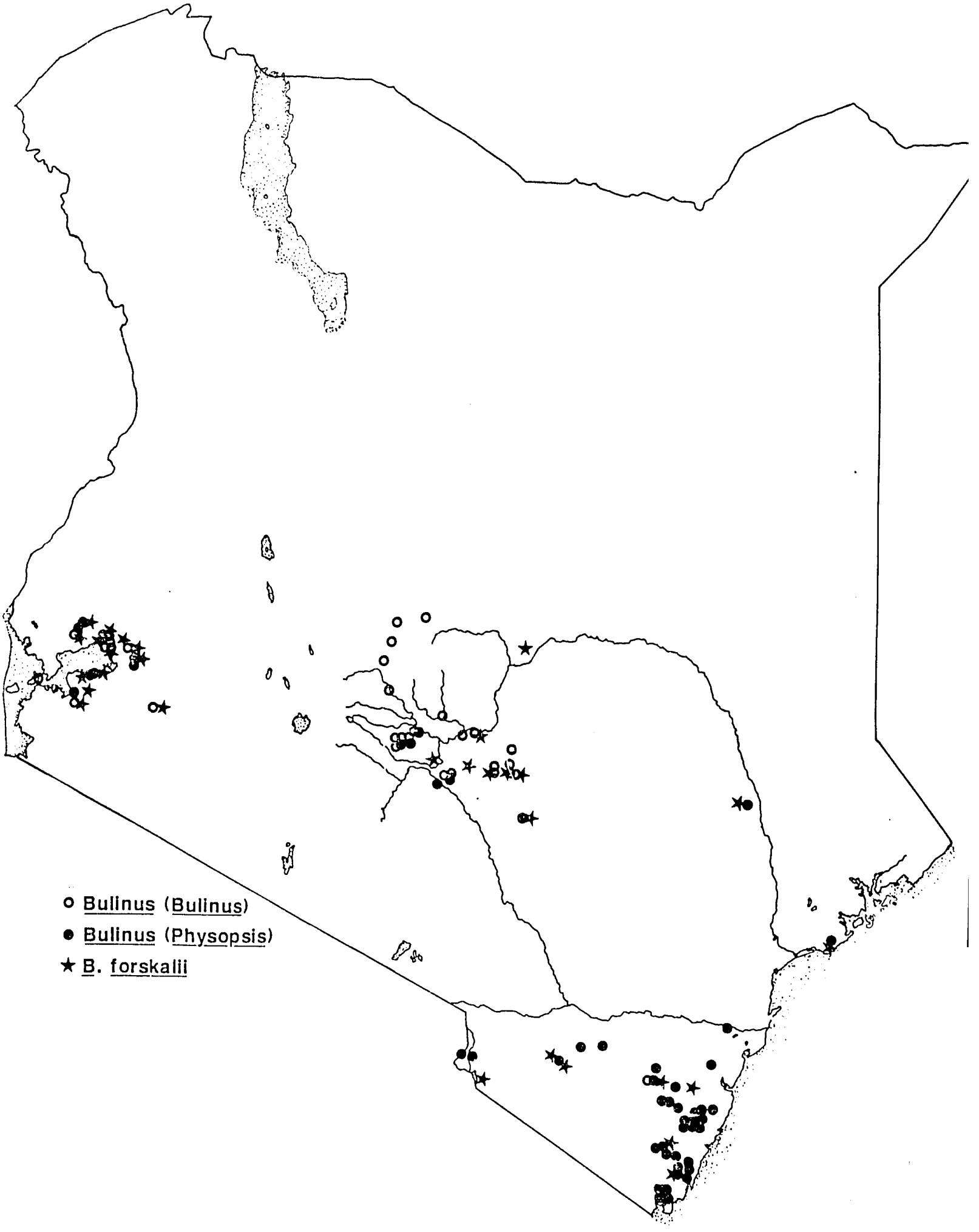

ALL COLLECTION LOCALITIES

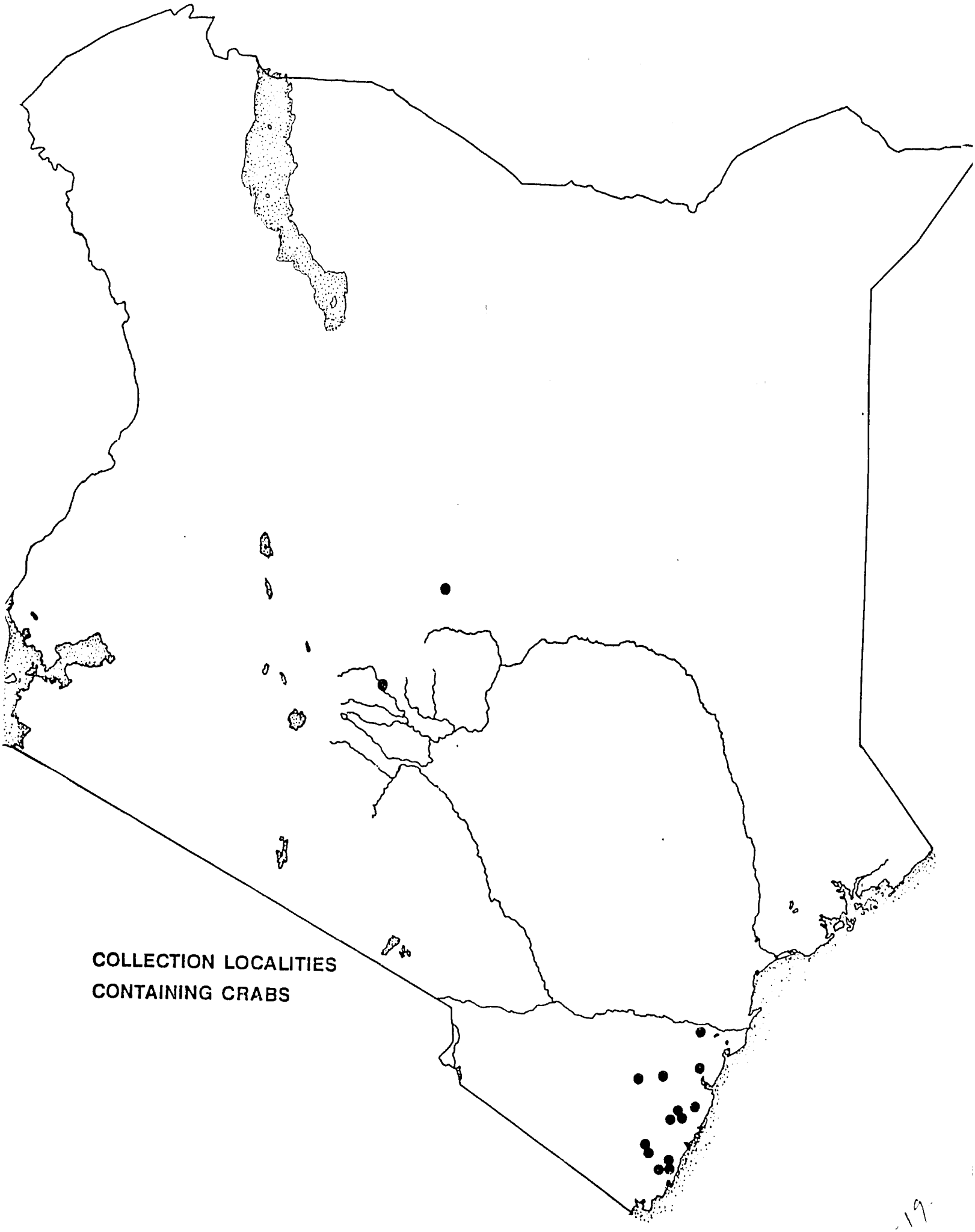

○ Biomphalaria sudanica
● B. pfeifferi
★ B. choanomphala


● Pila ovata
o Lanistes ovum
★ L. ciliatus
▼ L. carinatus


● Cleopatra ferruginea/bullmoides
○ Melanoides tuberculata


● Lymnaea natalensis
★ L. truncatula
○ Physa acuta


○ Bulinus (Bulinus)
● Bulinus (Physopsis)
★ B. forskalii


COLLECTION LOCALITIES
CONTAINING CRABS

NAME	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisarnsis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa cuta	Pila ovata	L. ovum ovum	L. ovum proceteus	L. ovum purpureus	L. ciliatus	L. carinatus	B. unic lor	B. trochlearis	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella hunerosa	Gabbiella parvipila	Ferrissia kavirondiv.	Ferrissia clessiniana
Matingani	1	2	~~-~~	1° 7'S	37° 53'E	-	8	1	1	1	-	-	276	-	-	-	29	-	-	-	-	-	-	25	-	-	-	-	-	-	-	-	318	-	-	-	-	-	-
Matingani Dam	2	2	-	1° 7'S	37° 53'E	-	7	1	1	1	-	-	-	-	-	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muthamo Dam	3	2	-	1° 8.4S	38° 2.7'E	-	7	1	1	1	-	-	4	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1P	-	-	-	-	-	-
Muthamo Dam Spillway	4	2	-	1° 8.4S	38° 2.7'E	-	8	1	1	1	-	-	-	-	-	-	135	8	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muthamo Seepage	5	2	-	1° 8.4S	38° 2.7'E	-	8	1	1	1	-	-	78	-	-	-	45	-	-	-	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Migwani Seepage	6	2	-	1° 4.8S	39° 2.1'E	-	8	1	1	1	-	-	2	-	-	-	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mbondoni Dam	7	2	-	0° 57'S	39° 2.4E	-	7	1	1	1	-	-	16	-	-	-	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	255	-	-	-	-	-	-
Kwakasoa Mbitini Dam	8	2	-	1° 29.7'S	39° 9.5E	-	7	1	1	1	-	-	-	-	-	139	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kangonde Dam	9	2	-	1° 2.1'S	37° 43'E	-	7	1	1	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	273	-	-	-	-	-	-

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. ciliatus	L. carinatus	D. unicolor	B. trochlearis	M. tuberculata	Cleo. ferruginea	Cleo. bulinoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondi	Ferrissia clessiniar
Kangonde Seepage	10	2	-	1° 2.1'S	37° 43'S	-	8	1	1	1	-	-	-	-	-	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mwea - East	11	4	-	-	-	-	3	1	1	1	-	-	289	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-	77	-	-	-	-	-	-
Mwea - West	12	4	-	-	-	-	3	1	1	1	-	-	70	-	-	-	16	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Nairobi Dam	13	5	-	1° 17.2S	36° 52'E	-	7	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	M = many
Gregan Canal	14	1	-	3° 25.5S	37° 44.5E	-	2	1	1	1	-	-	175	-	-	191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lake Jipe	15	1	-	3° 3~~4~~.5'S	37° 46~~6~~E	-	10	1	1	1	-	-	-	60	-	-	-	5	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kwahoma Str.	16	1	-	3° 23.5'~~4~~	37° 39.4E	-	2	1	1	1	-	-	66	-	-	1	-	-	-	-	-	-	-	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mtawa Stream	17	1	-	4° 20.7'S	39° 29.5'E	-	2	1	1	1	-	-	-	-	-	61	-	3	-	-	-	-	-	48	-	-	2	-	-	-	-	-	37	-	-	-	-	-	-
Muhaka Dam	18	1	-	4° 17.8S	39° 30.2E	-	7	1	1	1	-	-	-	-	-	33	-	-	-	-	-	-	-	2	-	-	-	-	-	21	-	-	3	-	-	-	-	-	-
Prov. Hdgrs Pond	19	1	-	4° 3.9S	39° 40.7E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M = many

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sucanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. ciliatus	L. carinatus	B. unicolor	B. truncatularis	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv	Ferrissia clessinian
Mazeras Bot. Gard	20	1	-	3° 57.7S	39° 33.0E	-	3	1	1	1	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-
Mazeras Gard - Cist	21	1	-	3° 57.7S	39° 33.0E	-	11	1	1	1	-	-	-	-	-	63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	-	-	-	-	-
Bamburi Site #1	22	1	-	3° 58.8S	39° 43.1E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	53	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-
Bamburi Site #2	23	1	-	3° 58.8S	39° 43.1E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	188	-	-	-	-	-	-	-	-	-	-	-	58	-	-	-	-	-
Bamburi Site #3	24	1	-	3° 58.8E	39° 43.1E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	189	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-
Chem-Chem Swamp	25	1	-	3° 12.3S	40° 2.3E	-	4	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	60	1	-	-	-	-
Stardust Orn. Pool	26	1	-	3° 11.6S	40° 6.9E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-
Eden Roc Hotel Pool	27	1	-	3° 11.6S	40° 6.9E	-	11	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	M	-	-	-	-	-
Asawo Stream	28	7	-	0° 16.3S	34° 59.4E	-	2	1	1	1	-	-	236	-	-	1	-	-	4	-	-	4	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ndori Dam	29	7	-	0° 15.4S	34° 59.5E	-	7	1	1	1	-	-	-	-	-	29	-	137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M = many

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. preifferi	Biom sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. ciliatus	L. carinatus	B. unicolor	B. tranchinaris	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv	Ferrissia clessinian.
Kisumu Ditch	30	7	-	0° 5.9S	34° 46.3E	-	6	1	1	1	-	-	-	-	-	-	10	9	6	-	-	-	-	11	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-
Martin's Drain	31	7	-	0° 5.9S	34° 46.3E	-	2	1	1	1	-	-	-	74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Old Prison Farm	32	7	-	0° 6.5S	34° 44.5E	-	6	1	1	1	-	-	1	-	-	12	-	2	1	-	-	-	-	2	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-
Dunga - L. Victoria	33	7	-	0° 5.0S	34° 44.2E	-	10	1	1	1	-	-	-	-	-	5	-	-	4	-	-	-	-	-	-	-	17	-	-	-	-	-	58	-	-	-	-	-	-
Hippo Point	34	7	-	0° 7.4S	34° 44.2E	-	10	1	1	1	-	-	-	-	-	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
ADC Farm	35	7	-	0° 4.7S	34° 44.5E	-	5	1	1	1	-	-	-	117	-	-	40	-	-	-	-	-	-	17	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-
West Kano Irr. Syst.	36	7	-	0° 5.0S	34° 49.3E	-	5	1	1	1	-	-	-	-	-	-	28	3	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Lake Jilori	37	1	-	3° 11.4S	39° 53.2E	-	4	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Dzimbwini-West	38	1	-	3° 9.1S	39° 50.9E	-	9	7	1	1	-	-	-	-	-	89	-	-	-	-	-	-	-	-	-	-	-	-	-	39	-	-	-	2	-	290	3	-	-	-
Dzimbwini-East	39	1	-	3° 9.1S	39° 50.9E	-	9	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	13	-	8	-	-	-	-

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom. sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. ciliatus	L. carinatus	B. unicolor	B. trochlearis	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv	Ferrissia clessinian.
Mbaratum Goshi	40	1	-	3° 11.0S	39° 45.4E	-	4	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-
L. Gulamu Ng'onda	41	1	-	3° 6.3S	39° 45.5E	-	10	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	46	-	-	27	-	-	-	138	-	24	-	-	-	-
Rare River	42	1	-	3° 31.1S	39° ~~45.4E~~ 45.4E	-	2	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-	-	M	-	-	-	-	-
Kachororoni Dam	43	~~2~~ 1	-	3° 29.0S	39° 42.7E	-	7	7	1	1	-	-	-	-	-	57	-	-	1	-	-	-	-	-	-	-	16	-	-	-	-	-	-	1	87	-	-	-	-	-
Ganze Dam	44	1	-	3° 34.1S	39° 41.1E	-	3	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	F	-	-	-	-
Ndizovuni Stream	45	1	-	3° 36.4S	39° 29.2E	-	2	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-
Mwachi River	46	1	-	3° 57.9S	39° 31.4E	-	2	7	1	1	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	21	-	-	273	-	-	-	6	-
Mbandi Stream	47	1	-	4° 7.8S	39° 20.2E	-	2	7	1	1	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	57	-	-	-	-	-
Kiziamondo Stream	48	1	-	4° 7.9S	39° 19.8E	-	2	7	1	1	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	32	-	-	-	-	-	-	117	-	-	-	-	-
Kinanago Dam	49	1	-	4° 7.9S	39° 18.8E	-	3	7	1	1	-	-	-	-	-	52	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	11	-	-	-	-	-	-	-	-

F = few

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kannisaensis	Lent. junodi .	Gyr. costulatus	Helisoma duryi	L.natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum proceereus	L. ovum purpureus	L. ciliatus	L. carinatus	G. unicolor	B. trochlearis	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv	Ferrissia clessiniana
Bububu Dam	50	1	-	4° 14.4S	39° 34.3E	-	3	7	1	1	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shanu Dam	51	1	-	4° 17.3S	39° 30.4E	-	7	7	1	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mkurumuji Str.	52	1	-	4° 21.5S	39° 26.9E	-	2	7	1	1	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Kambe Stream	53	1	-	4° 26.4S	39° 18.9E	-	2	7	1	1	-	-	-	-	-	21	-	-	-	-	-	-	-	-	36	-	-	-	-	-	-	-	137	-	-	-	-	6
Kikegu Village	51	1	-	4° 37.6S	39° 12.5E	-	12	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Mwangei	55	1	-	4° 30.6S	39° 16.8E	-	4	7	1	1	-	-	-	-	-	27	-	-	-	-	-	-	-	-	-	75	-	-	-	27	-	-	1	-	-	-	-	-
Mangewa River	56	1	-	3° 47.3S	39° 22.8E	-	2	7	1	1	-	-	-	-	-	38	-	-	-	-	-	-	-	-	-	-	-	-	-	94	-	-	84	-	-	-	-	-
Chumvi River	57	2	-	2° 15.1S	37° 48.7E	-	2	7	1	1	-	-	32	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kisumu-Hona Pond	58	7	-	0° 10.1S	34° 54.9E	-	3	7	1	1	-	-	-	-	-	3	11	3	1	-	-	-	-	11	-	-	38	-	-	-	-	-	-	-	-	-	-	-	-

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sugenica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. ciliatus	L. carinatus	O. unicolor	O. trochlearis	M. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv	Ferrissia clessinian
Kerbija Dam	59	7	-	0° 2.4S	34° 30.9E	-	7	7	1	1	-	-	-	-	-	-	8	5	4	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyachido Stream	60	7	-	0° 2.7S	34° 24.9E	-	2	7	1	1	-	-	13	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyangun Stream	61	7	-	0° 1.8S	34° 26.7E	-	2	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Dago Stream	62	7	-	0° 0.6N	34° 32.7E	-	2	7	1	1	-	-	-	-	-	5	-	-	2	-	-	-	-	-	-	-	25	-	-	-	-	-	-	-	-	-	-	-	-
Otodo Stream	63	7	-	0° 3.0N	34° 34.1E	-	2	7	1	1	-	-	-	-	-	1	-	1	-	-	-	-	-	1	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-
Kendu Bay	64	7	-	0° 20.4S	34° 39.0E	-	10	7	1	1	-	-	-	409	-	-	50	3	1	9	-	-	-	2	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-
Oriang Stream	65	7	-	0° 23.8S	34° 35.6E	-	2	7	1	1	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Got Okii Dam	66	7	-	0° 26.1S	34° 33.9E	-	3	7	1	1	-	-	-	-	-	-	-	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mango Stream	67	7	-	0° 28.5S	34° 32.7E	-	12	7	1	1	-	-	-	-	-	-	-	3	8	-	-	-	-	-	-	-	8	-	-	-	-	-	11	-	-	-	-	-	Cleopatra is guillemei

	HABITAT NUMBER	PROVINCE	DISTRICT	LATITUDE	LONGITUDE	ALTITUDE	HABITAT TYPE	MONTH	YEAR	COLLECTOR	Biom. choanomphala	Biom. pfeifferi	Biom sudanica	Bulinus (Physopsis)	Bulinus (Bulinus)	Bulinus forskalii	Cerato. natalensis	Seg. kanisaensis	Lent. junodi	Gyr. costulatus	Helisoma duryi	L. natalensis	Physa acuta	Pila ovata	L. ovum ovum	L. ovum procereus	L. ovum purpureus	L. cilliatus	L. carinatus	R. unicolor	B. trochlearis	H. tuberculata	Cleo. ferruginea	Cleo. bulimoides	Gabbiella humerosa	Gabbiella parvipila	Ferrissia kavirondiv.	Ferrissia clessiniana
Sota Stream	68	7	-	0° 30.6S	34° 28.8E	-	2	7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyalkiny Dam	69	7	-	0° 31.2S	34° 28.2E	-	7	7	1	1	-	-	-	-	-	31	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Pusinga Island	70	7	-	0° 24.9S	34° 12.3E	-	10	7	1	1	-	5	-	-	-	-	37	-	-	-	-	-	-	2	-	-	11	-	-	-	-	4	28	-	-	69	-	-	-
Kamayega Stream	71	7	-	0° 24.3S	34° 9.8E	-	2	7	1	1	-	-	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sero Dam	72	7	-	0° 35.6S	34° 29.7E	-	7	7	1	1	-	-	-	-	-	-	3	9	4	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Onsando Dam	73	7	-	0° 42.8S	35° 2.4E	-	7	7	1	1	-	-	125	-	-	-	-	-	-	-	-	-	-	86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kapcholyo Quarry	74	6	-	0° 39.2S	35° 8.0E	-	8	7	1	1	-	-	-	-	-	-	16	11	-	-	-	-	-	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taita Hills Lodge	75	1	-	3° 30.6S	38° 13.4E	-	7	7	1	2	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagalla Magange Str.	76	1	-	3° 29.1S	38° 24.3E	-	2	7	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lata Dam	77	1	-	3° 28.2S	38° 25.5E	-	7	7	1	2	-	-	749	-	-	-	-	X	-	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-