Dynamics of "Lymnaea natalensis" populations in the Zaria area (Nigeria) and the relation to "Fasciola gigantica" infections

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Dynamics of *Lymnaea natalensis* populations in the Zaria area (Nigeria) and the relation to *Fasciola gigantica* infections

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Summary

Observations on the seasonal changes in the *Lymnaea natalensis* population and the infection rate of these snails with *Fasciola gigantica* during 1972–1976 are reported. The data were obtained from snails in three different locations near Zaria in Northern Nigeria. One of the survey sites dried out during the drought of 1972–1974 and had to be abandoned.

The snail population showed seasonal variations with the lowest number of snails at the very end of the dry season. Many juvenile snails developed at the end of the wet season and beginning of the dry season, and the population reached its climax at the middle of the dry season.

Fasciola infections in the snails occurred throughout the year, but the majority of the infections appeared to be acquired during the end of the wet season resulting in a high infection rate (up to 25%) in the beginning of the dry season. There was evidence of accelerated growth and gigantism in the infected snails.

The occurrence of *Fasciola* infections in snails appears to depend on the presence (or absence) of livestock in snail infested areas during the rainy season. The infection developing in the rainy-season generation of snails is of major importance in the dissemination of fascioliasis in livestock as metacercarial shedding more or less coincides with the river-valley grazing of cattle.

Key words: Fasciola gigantica; Lymnaea natalensis; population dynamics; ecology; cattle movements; Nigeria.

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Introduction

Fifteen years ago, McCullough (1965), working in Ghana, observed that remarkably little was known in West Africa about *Lymnaea natalensis*, the snail intermediate host of *Fasciola gigantica*. Since then, various publications on fascioliasis, as reviewed by Schillhorn van Veen (1980), have appeared describing different aspects of the life cycle of snail and parasite. These reports indicate that the infection rate of *Lymnaea* is highest during the cool dry season, but no detailed information is available on the seasonal incidence of larval *Fasciola* infections in snails under field conditions. Birgi and Graber (1969) in Chad reported on the development in snails cultured in outdoor-tanks and observed a "maximum population" during the cool dry season (November to February).

During 1970–1971, *L. natalensis* was quite commonly observed in the streams in the Zaria area and a study on the seasonal population changes was initiated. Unfortunately, the intended study was seriously disturbed by the increasing droughty conditions culminating in the "Sahel-drought" of 1973–1974; many survey-sites had to be abandoned or changed as they dried out and snails disappeared. Despite these restrictions, the information gathered in the period 1971–1977 may still contribute to the knowledge on the lifecycle of *F. gigantica* in West Africa.

Materials and methods

The Zaria area

The area is part of the extensive Zaria-Kano peneplains developed on crystalline metamorphic rock of the Nigerian Basement Complex. Residual granite inselbergs provide some relief, especially southeastwards from Zaria City. The area is dissected by the Galma and the Tubo rivers; both belonging to the Kaduna-river drainage system (Fig. 1). Most streams in the area, apart from these two rivers, are seasonal, although some have surface water along stretches throughout the year. The river and stream valleys are fairly wide, especially in the eastern parts of the area, and are seasonally flooded creating wide continuous floodplains (fadama's). Towards the head-ends of the streams, the valleys are narrower with fairly steep gradients creating local gullying and discontinuous fadama's.

The climate

The tropical continental climate in the Zaria area, 700 km away from the sea, is determined by the movements of the dry Saharan airmass in the north and the moist Atlantic airmass in the south. The humid air is predominant during the period March to October; the dry northern wind blows during the period November to February. The rainy period generally lasts from the beginning of May to October. The cool dry season, characterized by a very low humidity (often below 15%) and a wide diurnal range in temperature (10–35° C), lasts from November to February. The climatic conditions during the survey period 1972–1977 varied considerably. Generally, the period was drier than normal and 1972 and 1973 were markedly dry due to abnormalities in the amount and distribution of rainfall.

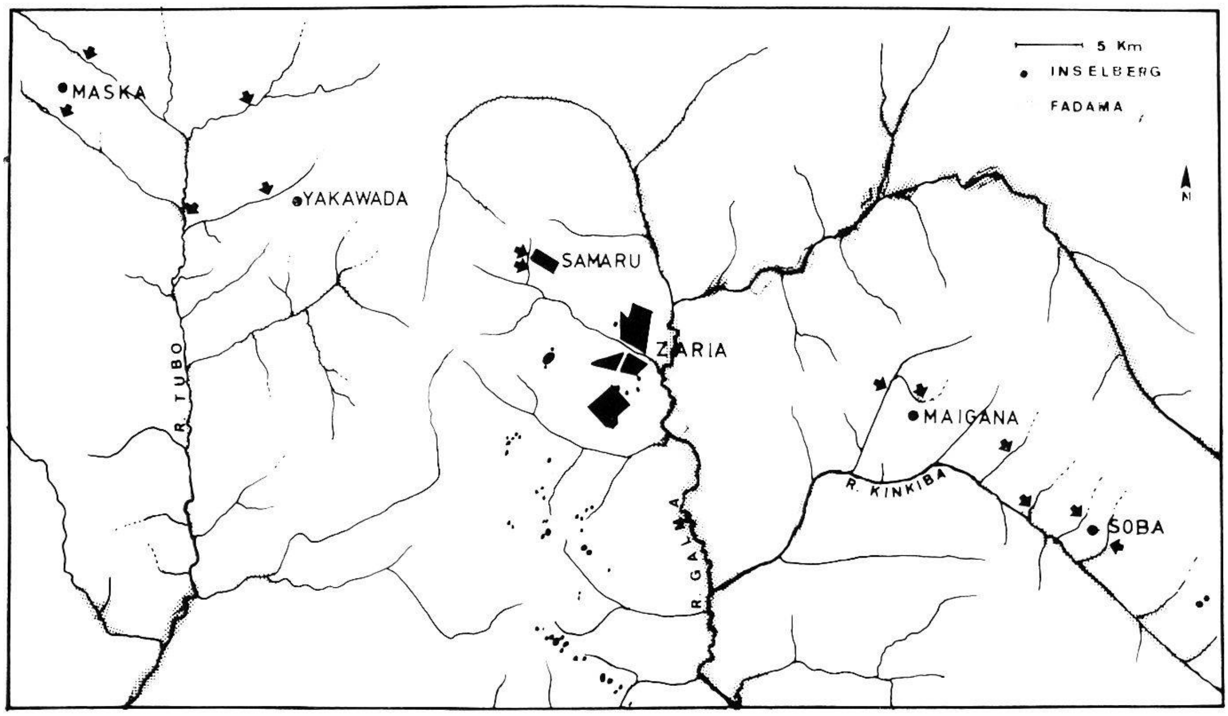

Fig. 1. The survey area in Zaria province (the arrows indicate the sampling sites).

Vegetation

The Zaria area is situated in the northern Guinea vegetational zone (Keay, 1959) and consists of cultivated park-land interspersed with woodlands. The vegetation in the streams and pools consists mainly of *Nymphaea* spp. and *Leersia hexandra.* Other species found in and near streams are *Commelina, Jussiaea,* and *Echinochloa* spp. Some streams and pools are partly overshadowed by *Raphia, Vitex,* and *Ficus* spp.

The survey sites

Snails were collected from three survey areas (Fig. 1).

1. *The Tubo river drainage system near Yakawada.* This area was characterized by a high percentage cultivated farmland cut by some small sluggish rainfed streams which, during the 1972–1974 drought, did all dry up, forcing us to abandon this site and move to a wetter area. The floodplains of these streams were small and were often cultivated (under irrigation). There were only a few settled livestock owners, but a considerable number of nomadic livestock passed through the area during their biannual migration north- or southwards.
2. *The Samaru stream.* This permanent stream was mainly fed by run-off from the Samaru village as well as by the effluent of the local slaughterslab, approximately 500–700 meters upstream from the collecting sites. In the dry season, seepage, presumed to come from a perched watertable, augmented the total water supply. The surveyed part of the stream was rarely visited by cattle, but the water was contaminated daily with faeces and other organic waste material from the nearby slaughter site. Various aspects of the aquatic life in the stream have been described by Smith (1975).
3. *The Kinkiba river drainage system near Soba and Maigana.* This area was characterized by fairly wide floodplains along the river and feeding streams. Most streams had some stretches which contained water throughout the year even during the drought. The cattle population, of which a fair number were permanently settled, was more dense than in the Maska area.

Snail sampling

Snails were collected by hand at two weekly intervals. The mean number collected in 5 minutes by one person was calculated and all snails were taken to the laboratory for examination. In the laboratory, the shell length was measured, after which the snails were crushed and examined under a dissection microscope. Snail eggs and very young snails (brood with a shell length of less than 5 mm) were not enumerated or routinely examined for larval trematode infections, but their presence was qualitatively recorded.

Water temperature and pH

During 1972, the water temperature in 5 streams in the Maska/Yakawada area was recorded weekly between 8 and 10 a.m. at 10 cm depth using a mercury thermometer. The pH of water samples obtained from the same sites was determined in the laboratory within 4 hours of collection using a Beckman pH meter. The mean pH of the weekly samples was calculated. During sampling, the vegetation in the streams was closely examined for the presence of *Lymnaea* eggs.

Results

Water: The water temperature, recorded during 1972 only, ranged between 24 and 27° C in the rainy season and between 13 and 18° C in the middle of the dry season, increasing to 25–29° C at the end of the dry season. The pH was over 7 during the dry season, but decreased as soon as the rains started (Fig. 2).

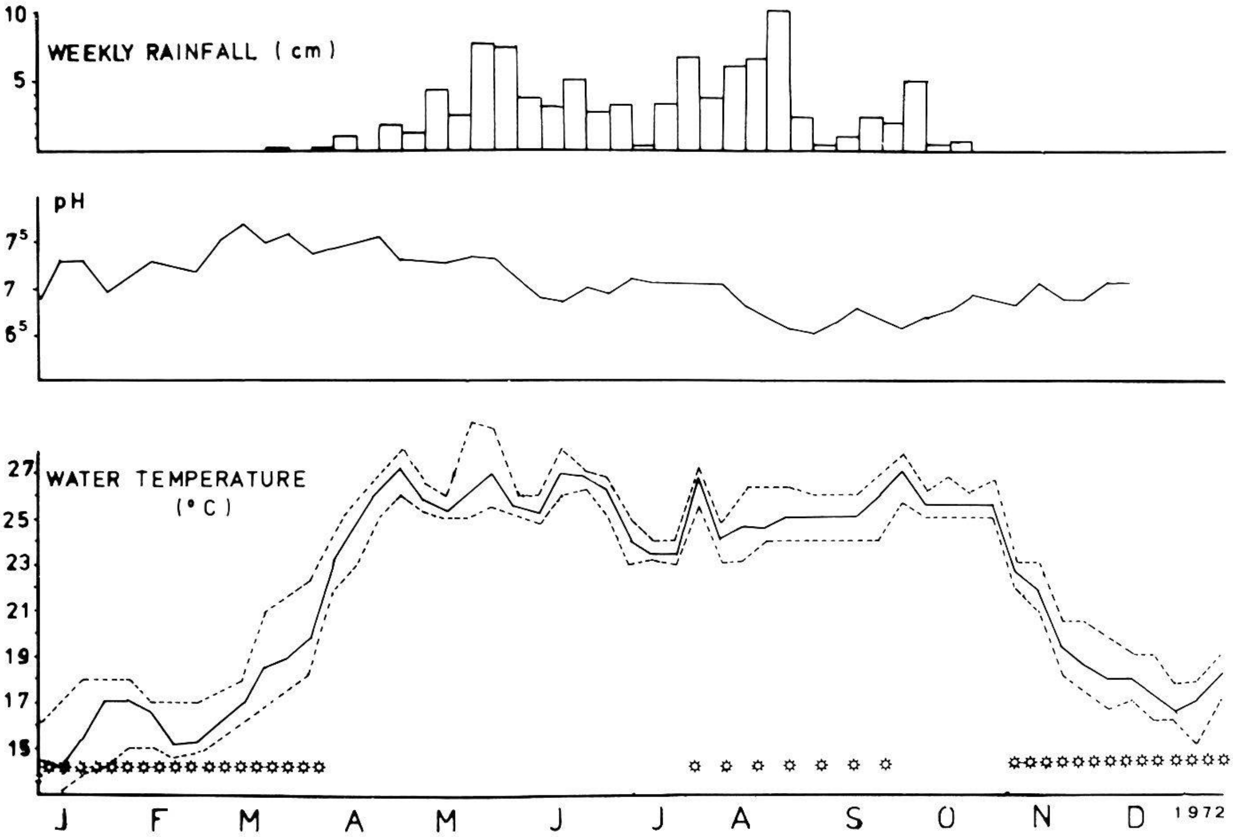

Fig. 2. The temperature, mean (——), range (.....), and pH of the water in the survey sites along the Tubo river (the asterisks indicate the observation of *Lymnaea eggs*).

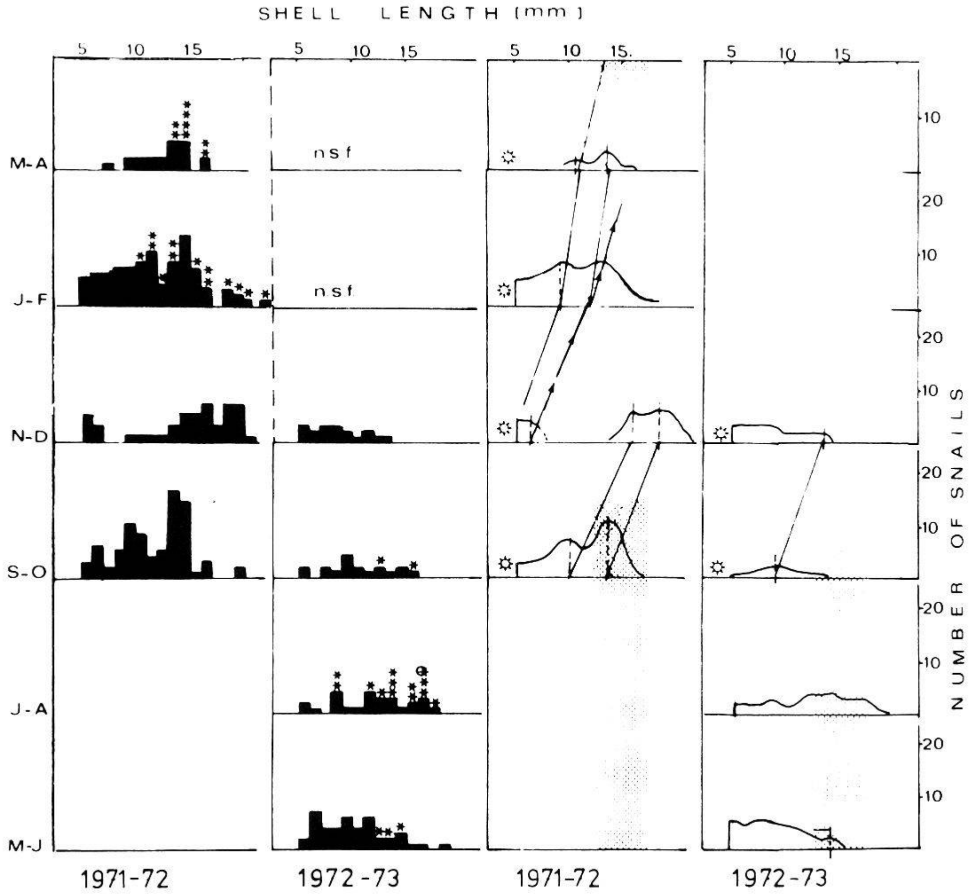

Fig. 3. Frequency distribution of shell length of *Lymnaea* snails in Tubo river system. The left graph shows the actual numbers; the asterisks indicate *Fasciola* infected snails. The right graph shows the floating average of the number of snails. The lines indicate the normal growth. The arrows indicate the accelerated growth of infected snails. The shaded areas represented the duration of the rainy period.

Snails: The major snail species found were *Lymnaea natalensis*, *Bulinus globosus*, *Biomphalaria pfeifferi* and *B. forskalli*, the latter species, however, only during the wet season. Occasionally, some smaller snail species, i.e. *Ferrisia* spp. and *Anisus* spp., were encountered.

Lymnaea eggs were mainly found during the dry season. The low number found during the wet season could be biased, however, as the abundant vegetation and high water level hindered the sampling. No snail eggs were found during the hot dry season. The number of snails collected each sampling was lower than originally estimated. Larger collections, however, would have affected the population of *L. natalensis*. On the other hand, the limited number of snails removed each sampling and the subsequent low total number of snails examined complicates the interpretation of the results. To obtain a workable number of snails in the size-frequency histograms, the data on snails collected over a two-month period were pooled and this probably widened the growth-peaks as snails could grow approximately 2–4 mm within the period. This is partly the reason why the size-frequency histograms prepared from the raw data (Figs. 3–5) show a rather erratic size distribution. The smoothed graphs, by

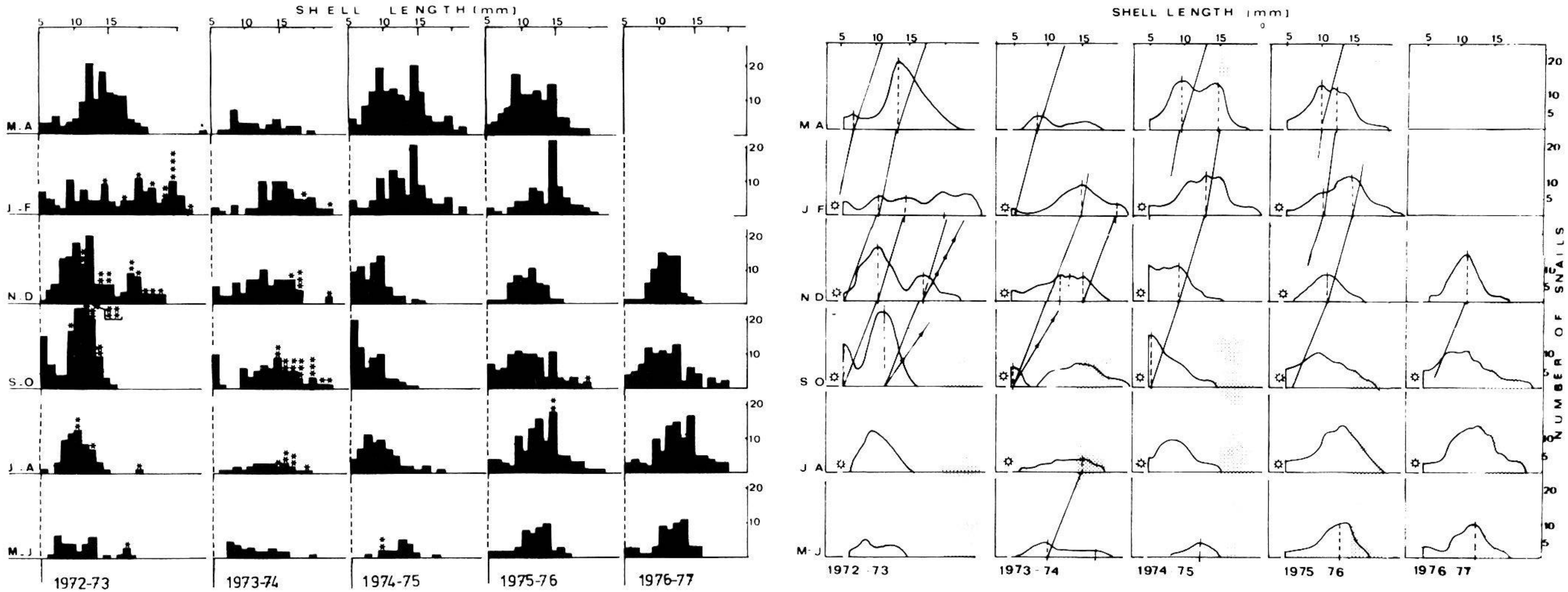

Fig. 4. Frequency distribution of shell length of *Lymnaea* snails in Samaru stream (see Fig. 3 for explanation).

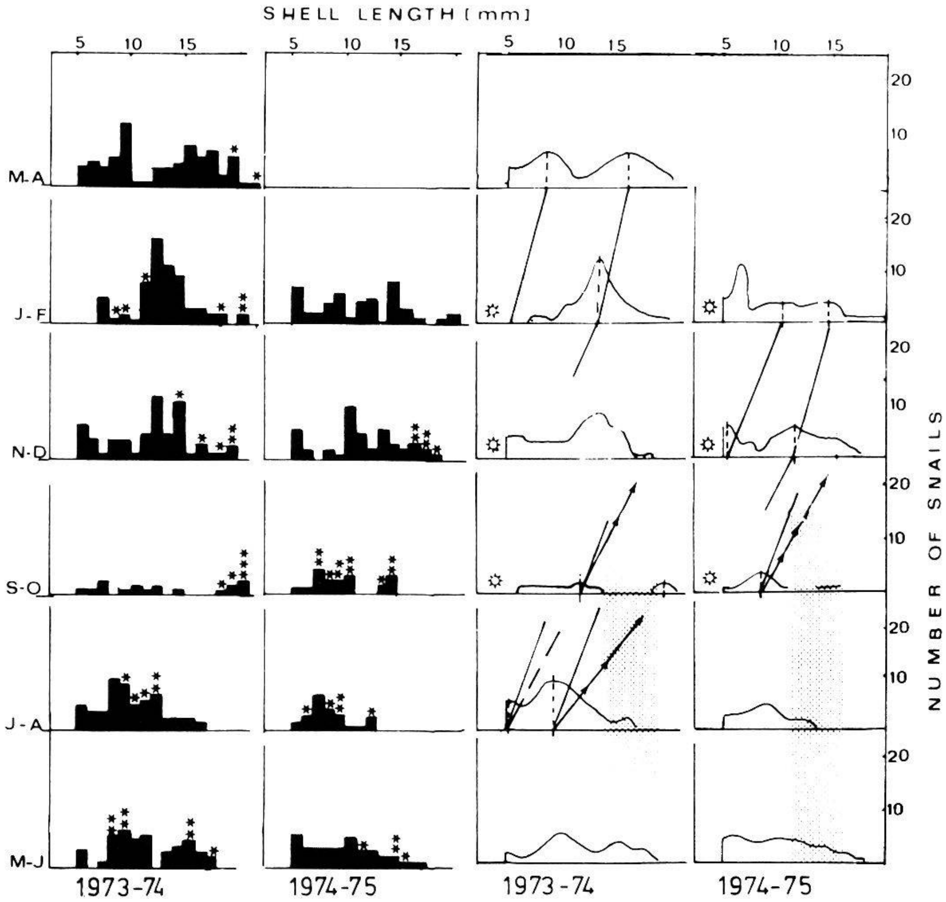

Fig. 5. Frequency distribution of shell length of *Lymnaea* snails in Kinkiba river system (see Fig. 3 for explanation).

means of a floating average, provide some identifiable patterns in snail development. The following observations were made in the three survey sites:

Tubo river system. Although the major parts of the streams dried out in the second half of the dry season, some stretches and pools contained water throughout the year until the dry season of 1972–1973 when these also dried out. The very few pools which (then) still contained water were heavily used by man and animals, and no snails could be found. During 1971–1972, *L. natalensis* was very common but disappeared gradually in the dry season of 1972–1973. *Fasciola*-infected snails were found during the dry season of 1971–1972 as well as during the rainy season of 1973 (Fig. 3).

The Samaru stream. Most stretches of the Samaru stream contained water throughout the survey period. The lowest number of *L. natalensis* was found when the water level was lowest (April to June). Breeding was rarely observed during this period but started again during the rainy season. The highest numbers, as well as the largest snails, occurred in the middle of the dry season (Fig. 4). *Fasciola*-infected snails were regularly found during 1972–1974, but rarely after 1974 (Fig. 6). The infection rate increased from the end of the wet season until December, after which it declined. Redial infections were most common during and directly after the rains.

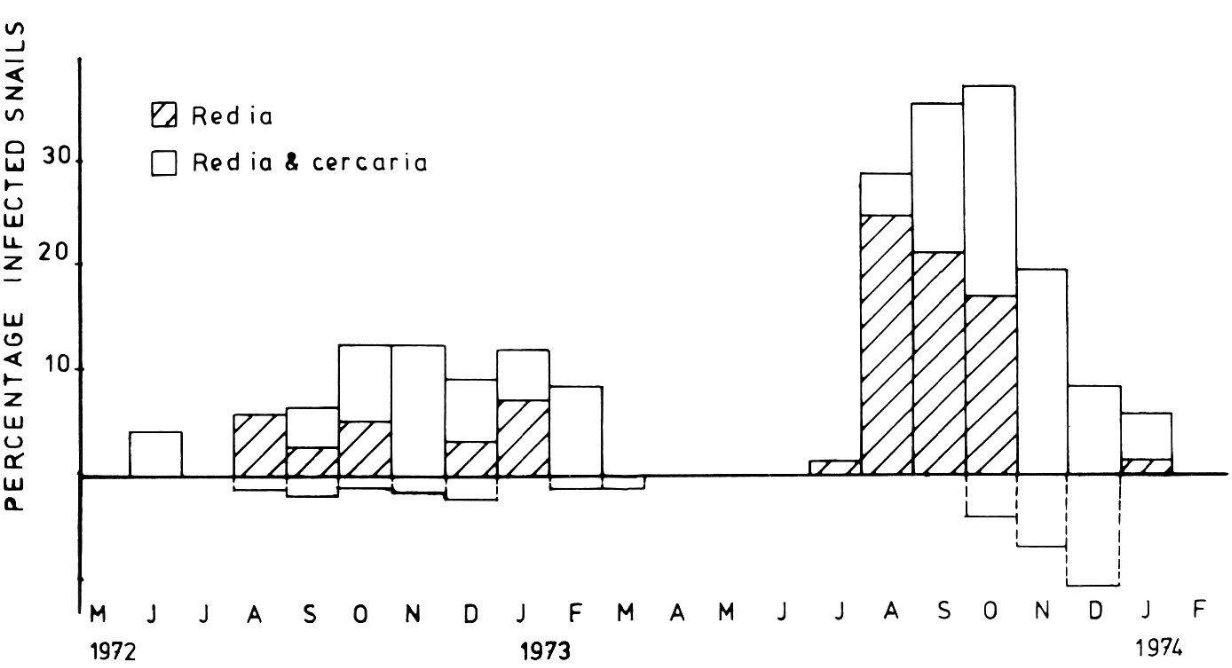

Fig. 6. Percentage of *Fasciola* infected snails among *L. natalensis* collected from Samaru stream (the bar below the line indicates the percentage infected with other larval trematodes).

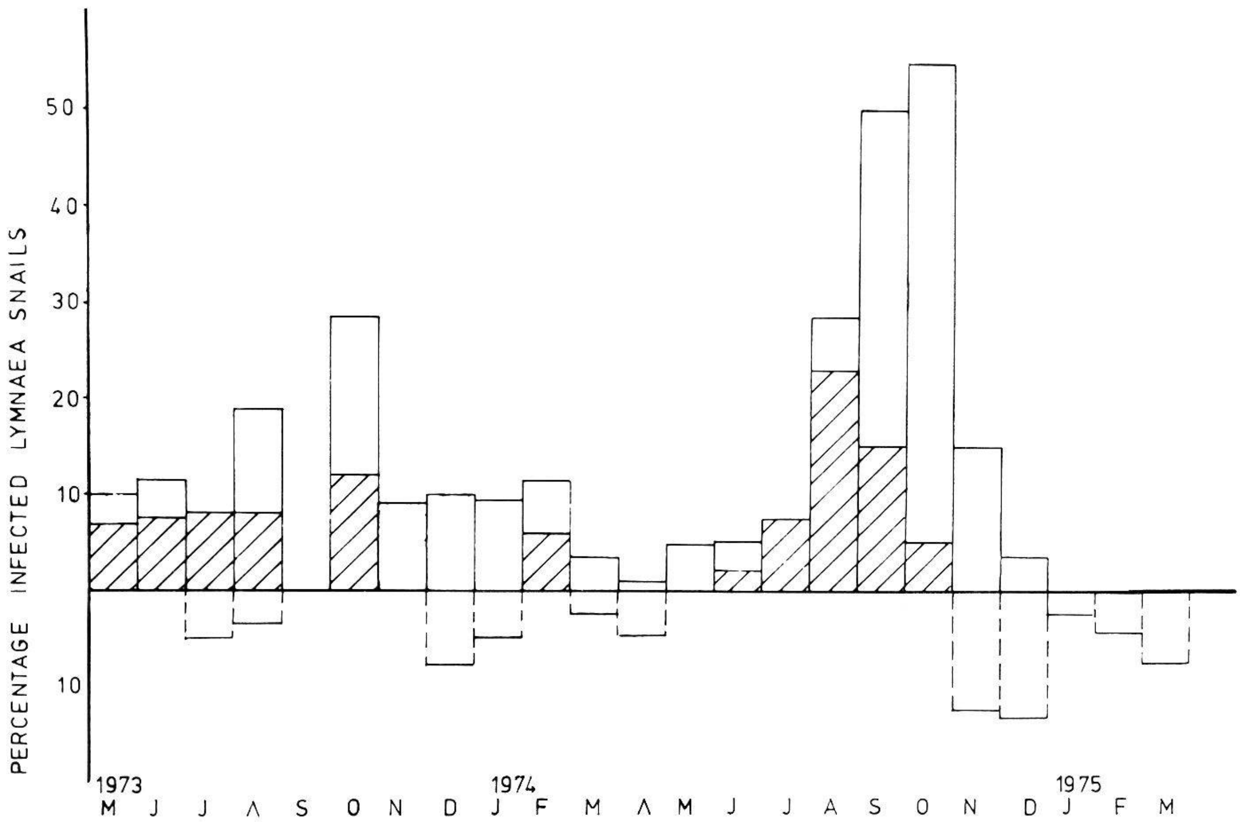

Fig. 7. Percentage of *Fasciola* infected snails among *L. natalensis* collected from Kinkiba river (for key see Fig. 6).

The Kinkiba river system. Despite the increasing dryness, most streams contained stretches of water throughout the dry season. Most stretches were flushed after heavy showers in the wet season, and then very few snails were found. Snail sampling at that time was difficult due to the flooding and abundant vegetation. *Fasciola*-infected *L. natalensis* were found throughout the year. The incidence of redial infections was highest during and directly after the rainy season (Fig. 7).

Discussion

Normal snail-growth and -breeding is mainly determined by the water temperature of the environment. Fig. 2 demonstrates that, in the Zaria area, roughly 5 periods with different water-temperatures can be identified: the rainy season with a fairly stable water-temperature of approximately 25° C, the beginning of the dry season when the temperature rapidly drops to the level of the following period; the cool dry season with a temperature ranging between 15 and 18° C; at the end of the dry season, the temperature gradually increases towards 25° C and the hot dry season, when it ranges between 25 and 28° C. Very little is known about the shell growth of *L. natalensis* at different temperatures, but extrapolation of the information provided by Pretorius and van Eeden (1969), Appleton (1974), and Séguin (1975) reveals an approximate growth of 2–2½ mm/month at 20–25° C and of 1–1½ mm/month at 10–15° C. Based on this information, the expected growth for the two-month periods was calculated and the expected growth lines have been plotted in Figs. 3–5. Some of these lines coincide indeed with the sequence of peaks the size-frequency histograms.

In the Samaru area then, there appear to develop at least two, and probably three, generations of snails in one year. One develops at the end of the rainy season and can, in most years, be traced until the beginning of the next rainy season. A second generation develops during the beginning of the dry season. There is some evidence, during 1972–1973 and 1973–1974, that a third generation developed at the end of the dry season. The snail population in the Tubo and Kinkiba river systems showed less easily recognizable patterns; the majority of the snails appeared to have developed either during the rainy season or in the middle of the dry season. These rather confusing patterns are partly due to the low number of snails collected but can also be associated with an accelerated growth of parasitized snails. Accelerated growth, probably resulting in gigantism, has been observed in other fluke infected *Lymnaea* spp. (Malek and Cheng, 1974), and could provide elegant solutions to the inexplicable growth pattern observed in Tubo and Kinkiba river as well as in Samaru during 1972–1974. The hypothetical accelerated growth of infected snails, based on information with other lymneaids (McClelland and Bourns, 1969; Over, 1971) and indicated in the graphs with arrows, coincides indeed with the actual growth patterns of infected snails in the Samaru stream during and after the wet season of 1972 and 1973, as well as with those in the Kinkiba system during 1973–1974 and 1974–1975. It is less apparent in the Tubo system.

The occurrence of redial and cercarial infections at the end of the rainy season is in accordance with the few observations made on snail infections in West Africa (Grétillat, 1961; Séguin, 1975; Cruz-e-Silva, 1974) and it appears that the rainy and beginning dry season generation of *L. natalensis* is probably the most important with regard to transmission of *F. gigantica.* The infection rate in the snail population is, of course, associated with the presence of miracidia in the environment or, in a wider context, with the presence of infected livestock in the area. As such, the three survey areas offer more or less typical examples of snail-cattle associations:

1. The Samaru stream was daily contaminated with cattle faeces throughout the year. The infection rate of the snails in the perennial stream was mainly determined by the presence of infected cattle in the slaughterhouse and by the development and survival of miracidia in the stream.
2. In the Tubo river area, very little grazing was possible during the wet season as all arable land was used for farming. Most of the semi-settled livestock owners moved their cattle away when the planting started and returned at harvest-time. An influx of migrating (semi)nomadic cattle occurred after harvesting during the middle of the dry season. Most of these herds stayed for some time in the area moving slowly southwards while grazing crop residues. As very few cattle were present in the area during the wet season, the chances of miracidial contamination and subsequent snail infection were small, and the "wet season" snail generation did not acquire a significant infection. Cattle returning in November and December, however, if infected with *Fasciola*, were the major source of infection for the next generation of snails, which matured during December to May.
3. In the Kinkiba area, a fair number of livestock owners were settled, but the cattle population increased considerably when (semi) nomadic livestock entered the area in the dry season. Faecal contamination, however, took place throughout the year. Still, the infection rate in the snails showed a definite seasonal pattern with the highest incidence during the end of the rainy season and beginning of the dry season.

There is an indication, when comparing the seasonal incidence of the infection with the growth lines of the snails (Figs. 3–5), that the rainy-season generation of snails shows the highest infection rate. This can be explained by the fact that, especially in the beginning of the rainy season, a considerable amount of (egg-containing) faeces is washed into the streams and rivers and subsequently developed into miracidia which infect the young snails present. Later in the wet season, the circumstances are less favorable for snail infection as the cattle population and subsequent faecal contamination decreased, and the total water volume, as well as the velocity, increased. Newly acquired snail infections, as demonstrated by the redial infection rate (Figs. 6 and 7), were appearing after October. Despite the increase in the cattle population during the dry season, there is little evidence of an increased infection rate in the snails. This can, to a certain extent, be due to the lower *Fasciola* egg-excretion rate of the cattle entering the area during the dry season (Schillhorn van Veen et al., 1980). It could also be snail-intrinsic.

The following epidemiological pattern emerges from these observations: The first generation of *Lymnaea* snails acquires the infection during the beginning of the rainy season. The number of miracidia is fairly high as the egg excretion of livestock is highest during that period (Schillhorn van Veen et al., 1980). Moreover, the egg survival and miracidium/snail contact is better during the rainy season. During the dry season, only those eggs dropped in or nearby water have a chance of further development. Cercarial shedding, during the cool dry season, coincides with the lowering of the watertable in floodplains. Cattle moving into recently dried-up floodplains in January to February risk fluke infection and may show signs of chronic fascioliasis during May to July. This pattern is less apparent when cattle are not present in the area during the snail-contamination phase (end of the dry, and beginning of the rainy season). Inhibited cercarial development during the cold months, as reported from East Africa (Dinnik and Dinnik, 1963), appears of little importance in the total epidemiology of *F. gigantica* in the Nigerian savanna.

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