NOTES ON THE BIOLOGY OF THE CARPET VIPER, ECHIS CARINATUS PYRAMIDUM (Geoffroy), IN THE NORTHERN FRONTIER PROVINCE OF KENYA

By

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Introduction

The work owes its origin to an undertaking by Mr. J.H.E. Leakey and the author to collect the venom of carpet vipers for use in the production of antivenom. It was intended not only to collect venom but also to make a study of the biology of the vipers. The work is incomplete as the whole operation was plagued by numerous unavoidable hitches, but, as a study of the large amount of data collected has revealed some interesting points, and as it is unlikely that the work will ever be continued on the same scale, it has been considered desirable to publish a note outlining the results.

Camp was set up at Moille Hill, 10 miles north of Merille on the Isiolo - Marsabit road, and it was there that the captive snakes were kept and "milked" of their venom. A team of 8 Turkana snake collectors was employed and operated over an area of approximately 250 square miles extending, on either side of the main road, from Laisamis in the north almost to the Serolevi River in the south.

During the periods from the 27th October to the 11th December, 1962 and from the 7th January to the 13th March, 1963 a total of 6,933 carpet vipers were collected, measured, and recorded, together with data on weather conditions and locality. Precise measurements of rainfall, temperature and humidity were taken at the camp, but as collecting was often as far away as 20 miles, particularly in the latter half of the operation, this was of little value, so in these places signs of recent rain etc. were noted. These data have been fully investigated in an attempt to find out how these semi-desert reptiles are affected by rainfall.

The captives were kept in two pens of fine wire netting 30 ft in diameter. There were never more than 3,000 at a time as they began to show signs of starvation after a few weeks and were released while they were considered to have a good chance of surviving. They were all marked and not a single one was taken a second time. Much time was spent observing the behaviour of snakes in pens and this related to observations in the field.

It is a matter of considerable annoyance, that, due to the prevailing security situation in the area, the author is unable to return to Moille to obtain photographs badly needed for this paper, and to check on a number of points which have emerged only since the data have been exhaustively examined.

The Habitat

Where collecting was most successful there was scattered bush with very little grass cover on sandy soil; here the few large Acacia trees provided logs which were favoured by the snakes. Usually only the large heavy logs, well rotted and eaten by termites underneath, harboured carpet vipers. It was under such logs too, that skinks and geckos, scorpions, solifugids and centipedes, were to be found.

On numerous occasions apparently suitable logs were investigated where there was thick grass cover and no open ground; the results were invariably disappointing. A whole morning was spent in turning over enormous logs with the help of a Land-Rover on the banks of the Merille River where there was thick vegetation without taking a single specimen, yet a short distance away where there was open ground carpet vipers were found to be abundant under similar logs. It may be, and this seemed unlikely, that in such places they spend the day under tufts of grass and brushwood etc. and that this was in such abundance that they were difficult to find. On the other hand they may avoid thick cover as a direct result of their feeding behaviour. (This will be discussed later).

Numerous tracks of carpet vipers were to be seen on the ground in places where the sand was soft, many of these leading to and from rodent holes. This was true where there were good logs and where there were none as in the Kaisut Desert, and as the number of tracks that could be seen every day even in the heavily collected area around camp did not noticeably diminish throughout the period, it appears that the majority of the population, particularly the adults, spent the day in such holes.

The Population

The total length of each specimen collected was measured in centimetres; the smallest was 13 cm (one specimen), and the largest 69 cm (one specimen). They were considered to become adult at about 40 cm, all those smaller than this being juveniles and sub-adults.

The number of juveniles taken (under logs) outnumbered the adults by 10.7 to 1, which can hardly be a true value of their proportion of the population. There were 16 snakes caught out at night of which 1 was juvenile and 15 adult. Plotting the length against the number of specimens taken, graphs were drawn of the total catch in each week of collecting (16 in all), and this showed clearly one large peak of juveniles of which the mean value for size got progressively larger from the beginning to the end of the collecting period. This is illustrated in Fig. 1 with four graphs of approximately 2 weeks collecting separated by a period of 4 weeks. The small peak at about 18 cm in (d) is a new batch of young which will be investigated later.

Of each of the 16 graphs of one week of collecting the mean value for length in the main peak was taken and plotted as a graph covering 19 weeks (there was no collecting in week 8, 9, or 10) - Fig. 3 (a). It is important to note that although this clearly indicates that the snakes in the main peak are of about the same age, Fig. 3 (a) is not a growth curve. Firstly because in each week there were always some snakes in the 15 to 20 cm range showing that there were young being born all the time, which, merging with the main peak would hold it back,

and, secondly, from the proportion of small to large snakes collected it is apparent that, at any rate in the region of 25 to 40 cm the larger the snake the smaller the possibility that it will be taken by the collecting methods here employed, which would also hold back the progression of the main peak. A growth curve would, therefore, be considerably steeper than that in Fig. 3 (a), but it is unfortunately impossible to calculate a reasonably accurate factor for its correction.

The Effect of Rainfall

The position of the main peak of juveniles from week to week shown in Fig. 3 (a) shows some definite groupings of points above and below the curve drawn through them. This has been investigated from the point of view of lunar periodicity, differences of collecting area, humidity and rainfall. Only the latter two show any correlation at all. Fig. 3 (b) shows a graph of the average saturation deficit for each week taken with a wet and dry bulb hygrometer at 9.00 a.m. at the camp, (note that, as mentioned before, the collecting area grew further away from the camp as the operation proceeded until it was usually 15 to 20 miles distant). The thick horizontal lines at the bottom of Fig. 3 (a) indicate periods in which recent rainfall was noted as having occurred in the collecting area - generally an effort was made to go collecting where there had been rain.

A comparison of Figs. 3 (a) and (b) shows that the larger juveniles were more inclined to stay under logs when the ground was damp, and there was a lower saturation deficit, than during the dry periods.

Two peaks of births were found in the collection of the week of the 3rd to the 9th February, 1963, during which there was a good shower of rain (about the 7th and 8th), Fig. 2(b). Before this there was the usual small birth rate, Fig. 2 (a). These two peaks can be followed in the following four weeks - Fig. 2 (c), (d), (e) and (f) after which collecting ceased.

The positions of these two peaks in Fig. 2 are plotted in Fig. 4, and it will be seen that not only do they first appear in a different position but they progress very differently. The two peaks can not be separated by locality of collection as all in Fig. 2 were collected in the same area. Peak y appears to have arrived a little before x but not to the extent that would separate it so far, nor explain the very different curves in Fig. 4. It can only be supposed that the two curves consist of individuals of different sex and that the unlikely curve formed by x is due to it being held back in its progression by the continual small numer of births from which y has apparently managed to escape; notice, for instance, how the small peak z in Fig. 2 (e) (following another shower of rain) has merged into x in Fig.2 (f).

The curve of y in Fig. 4 looks like a true growth curve. If it is, and if the error in the curve formed by the position of the main peak (Fig. 3 (a)) be taken as small at its lower point, then these two curves may be joined together showing that the individuals in the main peak were born about 5 weeks previous to the first week of collecting, that is, towards the end of September 1962. The collecting area was very dry when first seen on the 24th of October and it was impossible to find out whether there had been any rain in the previous few weeks, certainly there was not much as there was no new green vegetation. According to the local herdsmen the rain was expected at the beginning

of October and they were migrating south to better grazing where there had been rain (more than 30 miles south). The first trace of rain in the collecting area came on the 27th October and there was little more until the 25th of November.

Fig. 3 (c) is a graph showing the proportion of newly born snakes each week, that is, those under 20 cm in length. There was no time when there were absolutely no births, however, there is a steady decline in the birth rate from the 3rd to the 7th week. When collecting was resumed in the 11th week the birth rate had returned to about its former level. This, together with Fig. 2 indicates a correlation between births and rainfall, the young being born mainly when the ground becomes wet. From this it follows, also, that the female snake must be able to delay giving birth for a few weeks while weather conditions are unsuitable for the young.

Among the captives there were three batches of eggs laid, one batch of 5 eggs in December 1962 and another two of 5 and 6 eggs in February 1963. The eggs contained no embryos and had perfect tough white shells, and as it was hard to imagine that these were immature or sterile, it was assumed that the snakes were oviparous. Furthermore, there were no births in the pens and such would certainly have been noticed as very small snakes were not put in the pens but were put aside in a box to be released when it was convenient. Here the author is indebted to Mr. C.J.P. Ionides and Captain Charles Pitman for expressing strong doubts that they are oviparous, and in particular to Captain Pitman for making extensive enquiries from which he was able to confirm that carpet vipers are definitely known to be ovo-viviparous. (See Wall, F. "The Snakes of Ceylon" 1921.) While assuming oviparity there are some awkward questions to be answered regarding the rate of emergence of the young.

Activity and Water Relations

The captive snakes became active towards sunset and were continually on the move until sunrise the next morning. On no occasion was a carpet viper seen in the open in the wild during the day, only one specimen was found emerging from a hole and that was at 6.00 p.m.

The rate of activity of the captives in the pens was certainly very high, and if they did not feed, and most did not, they became very thin after about four weeks. This of course, is not truly indicative of what happens in the wild state as the captives are bound to have been affected by overcrowding. However, there is some evidence of similar high activity in the wild and this is from the venom. Newly caught snakes were always milked of their venom before being put in the pens, they were milked again exactly one week later and this second milking always produced at least another half as much venom and this of a marked darker orange-yellow colour, indicating a high rate of venom discharge and a high rate of venom synthesis, i.e. in one week forcibly emptied venom glands became more heavily charged than they normally have a chance to in the wild.

After a week or two in the pens the snakes' skins became hard and wrinkled and those that were due to slough were unable to do so. As this was obviously due to the skin drying out, shallow ditches were dug on the side of each pen and covered with Papyrus grass matting and this was watered occasionally to keep the soil damp. It was hoped that the

snakes would take to spending the day under these mats, but this was not to be so, very few were found under the mats and these only on the tops of ridges between the troughs where their backs could be in contact with the matting, the remainder lying out in the open as usual in large tangled heaps of 40 to 100 individuals. After this failure every single snake was collected and "put to bed" in the new quarters, a long and tiresome job but with pleasing results as in a few days hundreds of new sloughs were to be found in the pens, some of them of two layers thick. Thereafter the skins remained in healthy condition.

Due to the severe effect of desiccation it would be misleading to draw conclusions as to the frequency of sloughing from the captives. Very few sloughs were seen in the field.

It is, then, of great importance that carpet vipers should spend the day in a microclimate of high humidity. As to how they choose suitable places is not at all clear and is presumably tied up in complexities of the general pattern of behaviour rather than a simple search for suitable conditions with the help of humidity receptors. Temperature may be an important guide as suitable retreats would be expected to have a higher temperature than that of the ground surface in the early morning, but then this does not explain why larger snakes are to be found under logs when the ground is damp. (Fig. 3).

The explanation for the proportionately small numbers of adults collected probably lies here. Nearly all the snakes taken were under logs and it seems reasonable that if a log had a hole beneath it that was big enough to take a large carpet viper then it would be dry. Most of the large snakes taken were probably the few that were caught out without a more suitable retreat. There would be no harm in spending the odd day under unsuitable logs and this they certainly did as a lot, of all sizes, (though small overall proportion) were found under dry, newly turned, logs.

The captives drank frequently from the troughs of water provided.

Feeding

From observations of faeces and regurgitated food the following were found to be included in the diet:-

Vertebrates:- Rodents, lizards.
Arthropods:- Solifugids, scorpions, centipedes.

One small specimen was taken in the early evening while swallowing a small frog.

Termites were often found in the faeces and occasionally small beetle and grasshopper remains, but all these could be put down to having been first eaten by the lizards which were subsequently eaten by snakes. During an enormous emergence of insects after the rain on the 27th October 1962 a lamp was hung over the pens at night and a few snakes were later found to have eaten beetles. Large tenebrionid beetles were always present beneath the mats but these were apparently never taken.

Dead scorpions, solifugids and centipedes were readily taken as also were dead lizards and mice. Spiny mice (Acomys sp.) which were

common in the area were, however, never eaten when left dead in the pens. When Acomys was first dismembered most of those parts with no spines were eaten but parts armed with spines were never eaten although these were often found to have been dragged far away from where they were originally put.

An attempt was made to feed the snakes on pieces of plain meat. The first piece of goat's meat which was put in the pen was immediately smelt by several snakes near it, and one, after quickly "licking it over", swallowed it. Many more pieces of meat were put in after this and on numerous subsequent occasions, mutton, beef and goat's meat were tried but not a single piece was ever eaten. It was intended to try flavouring pieces of meat with extracts of the normal food, but this experiment, like so many others, regretably never materialised.

Cannibalism was rife. It was seldom that the pens were visited at night without seeing at least one snake with its head gripped in another's mouth. The pair would remain motionless like this for several minutes then the one which had been caught would wriggle violently and then so would the attacker and the pair would skip across the pen in a most ridiculous fashion. The bite appeared to have no effect on the victim and this is probably why comparitively few were swallowed - the attacker waiting in vain for the victim to die. Carpet vipers were never seen to be bitten by their fellows anywhere but on the head.

The head biting was a great nuisance when it came to collecting venom as the venom glands were frequently punctured resulting in internal bleeding and mixing of blood with the venom stored in the glands. It was, however, useful as it enabled the method of attack to be observed on numerous occasions, and as the ground surface had, in places, become soft and powdery, distinct tracks were left which could be used to interpret similar tracks in the field.

The carpet viper is well known for the way in which it draws its body into loops and produces a continuous stridulation by rubbing the lateral scales, the keels of which are serrated, of one part of the body against another, the undulations moving from front to back and new loops being formed some way from the head so that the head can remain still in the same position all the time. Carpet vipers are very vicious and frequently attack for defence, the method of progression being to spring forward from the looped position, draw up the hind part of the body into stridulating loops again and spring forward again and so on. In this way they move at an alarming rate. The method of attacking each other in the pens was very similar only less time was wasted in forming close loops and there was no stridulating. This is a very efficient method of progression on flat ground and although it could probably never rival an accomplished sidewinder in speed is almost certainly far more effective on hard sand which is predominant in, at any rate, the habitat in which the population here under discussion was found. It is also a movement very suitable for chasing after and capturing an animal as at every few inches the body is drawn up into a striking position. In passing, this method of progression can be seen in crude form in many other snakes when striking repeatedly from a looped "stance" and its development to perfection in carpet vipers may have lead to the evolution of the stridulatory behaviour.

This mode of progression left very distinct tracks in the soft sand and these were frequently observed in the field. There would be

the normal single line tracks made by slow crawling on the ventral scales, then this would break off into the "attack movement" track for a short distance seldom exceeding 3 feet and leading off in any direction, then the single line track was resumed. This indicates that an important way of feeding is to move slowly over open ground and, on sighting suitable prey, make a short fast rush after it. If this is the main method of hunting then it explains why so few carpet vipers were found where there was not a lot of open ground. Unfortunately tracks of the prey were never seen in this connection because the sand was either too coarse to take small tracks, or if fine enough they would have been obliterated by the strong wind that always arose shortly before daybreak. The prey was certainly available in these places, geckos and solifugids in particular were often seen on open ground at night.

Tracks leading to and from rodent holes made in the same night were also frequently seen, so it may be that they visit these holes in the hope of finding the rodents at home, or any other animals taking refuge therein.

Enemies

The impression was gained that the carpet vipers had few natural enemies. The population was very large, the number of young produced small (batches of eggs laid numbered 5 or 6, and Colonel Wall states that there are from 3 to 15 in a brood) and, though nocturnal, they appear to take no pains to keep to cover, moving over flat open ground even on bright moonlit nights.

One evening a red cobra (Naja nigricollis pallida Boulenger) was seen and captured in one of the pens. In all two cobras were caught and one seen out at night, a fourth being discovered beneath a log in the daytime. Cobras are well known snake eaters and it is unlikely that they do not eat carpet vipers and, in fact, are very likely to be the carpet vipers main enemy.

A dead shrike was found near the pens one morning with haemorrhage in one leg and half the underside of the body. It had obviously tried to capture one of the carpet vipers lying out in the open.

Carpet vipers are extremely vicious natured and will rasp their scales and strike out in an impressive threat display at the smallest provocation. Presumably potential enemies are very wary of them, and this is supported by the fact that the egg-eaters (Dasypeltis) in the area very closely mimic them. The mimicry of colour and body pattern is so good that it is difficult to distinguish the two on pattern alone. (See photograph). By examining a series in the Coryndon Museum it has been found that the serrations on the lateral scales of these mimics are generally much more pronounced than they are on non mimic Dasypeltis in the southern part of Kenya. (Fig. 5).

The Venom

Venom extracted from newly caught snakes of about 30 cm and under dried to pale yellow, almost colourless, flakes. That of snakes of over 45 cm was a deep orange-yellow colour. After being in the pens a week they not only produced much more venom but it was a darker colour in both small and large snakes.

There were three cases pf snake-bite from carpet vipers among the collectors, one from a large specimen and two from small, and in all cases there was only one fang puncture. These were treated with specific antivenom and no serious symptoms developed. The author was bitten on three occasions by small snakes, also one fang puncture from each. The first was treated by cutting and applying rubber suction cups and the other two were neglected; only very local swelling and slight local discomfort was experienced in each case.

A sand boa, Eryx colubrinus loveridgei Stull, which was kept in one of the pens was found with a large swelling consisting of fluid lodged under the skin, it having presumably been bitten by a carpet viper. About a week later it was found again in healthy condition with no swelling and the skin in the region of the bite dry and hard.

The venom was collected in shallow watch glasses in a specially constructed apparatus, and as milking was done almost every day scraping out of dried venom also had to be done frequently. On two occasions (3 weeks after the first snake-bite) the author had great difficulty in performing this task due to severe smarting of the eyes and almost incessant sneezing. This was taken to be due to hypersensitivity acquired as a result of frequent exposure to venom dust. The day following the second experience a minute cut about 3 mm long was made in the skin of the upper forearm just deep enough to bleed slightly and a minute drop of fresh venom introduced into it. The effect was startling as the entrance and incredibly fast spread of venom could be clearly felt. Within 20 minutes the entire fore and upper arm felt distinctly but mildly bruised. There was no swelling, no enlargement of the lymph nodes and no general illness, and in 24 hours the strange bruised feeling of the arm had completely disappeared.

After a lapse of 48 hours the experiment was repeated with a slightly larger drop of venom and it was planned to measure accurately the rate of spread; however, there was no noticable effect whatsoever. At this stage it was found also, that scraping of dried venom could be performed without any trouble. After this cutting and introducing venom was done regularly every 4 or 5 days, the dose being increased from the start to a fairly large drop held in a deeper cut about ½ cm long for a minute or two with the forefinger. The effects were always mild, there being slight swelling of an inch in diameter accompanied by the bruised feeling; also, a small area immediately around the cut turned a dark brown colour. This was noticed also in the two bites that were not cut and bled.

If, as the author believes, this was a true case of hypersensitivity, the method of desensitising can be recommended to workers with snake venom as being painless, very effective, and requiring the minimum of time and apparatus.

Weight for weight carpet viper venom is very toxic and, due to their vicious nature, the snakes have a well deserved reputation of being dangerous. Local Rendille herdsmen who frequently came to view the snakes in the pens were often questioned on the subject. Apparently snake-bite from carpet vipers was not uncommon but, surprisingly, none of them knew of anyone who had died or even suffered permanent effects as a result of such a bite. Their method of cure was essentially to cut the wound open to cause bleeding and to feed the victim on burnt milk and goat's hide for 3 or 4 days as an emetic. Perhaps these

people owe their survival to the fact that it has, apparently, never occurred to them that it is a good idea to hold the venom in, and cut off the blood supply to the affected tissues by application of a ligature.

Acknowledgment

I am particularly indebted to Mr. and Mrs. J.H.E. Leakey for their invaluable help and cooperation in the field, and for doing much of the recording at the camp. My sincere thanks are also due to Captain C.R.S. Pitman for reading and criticising the manuscript, and to the staff of the Coryndon Museum for their help and encouragement.

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Post Script

Since going to press I have received a communication from Captain Pitman stating that recent, as yet unpublished work has shown that, whereas Indian *Echis carinatus* are ovo-viviparous, *E. carinatus* from Eritrea have been found to lay fertile eggs. Although there is no confirmation, it now seems even more probable that I was correct in my original belief that the population around Merille is truly oviparous.

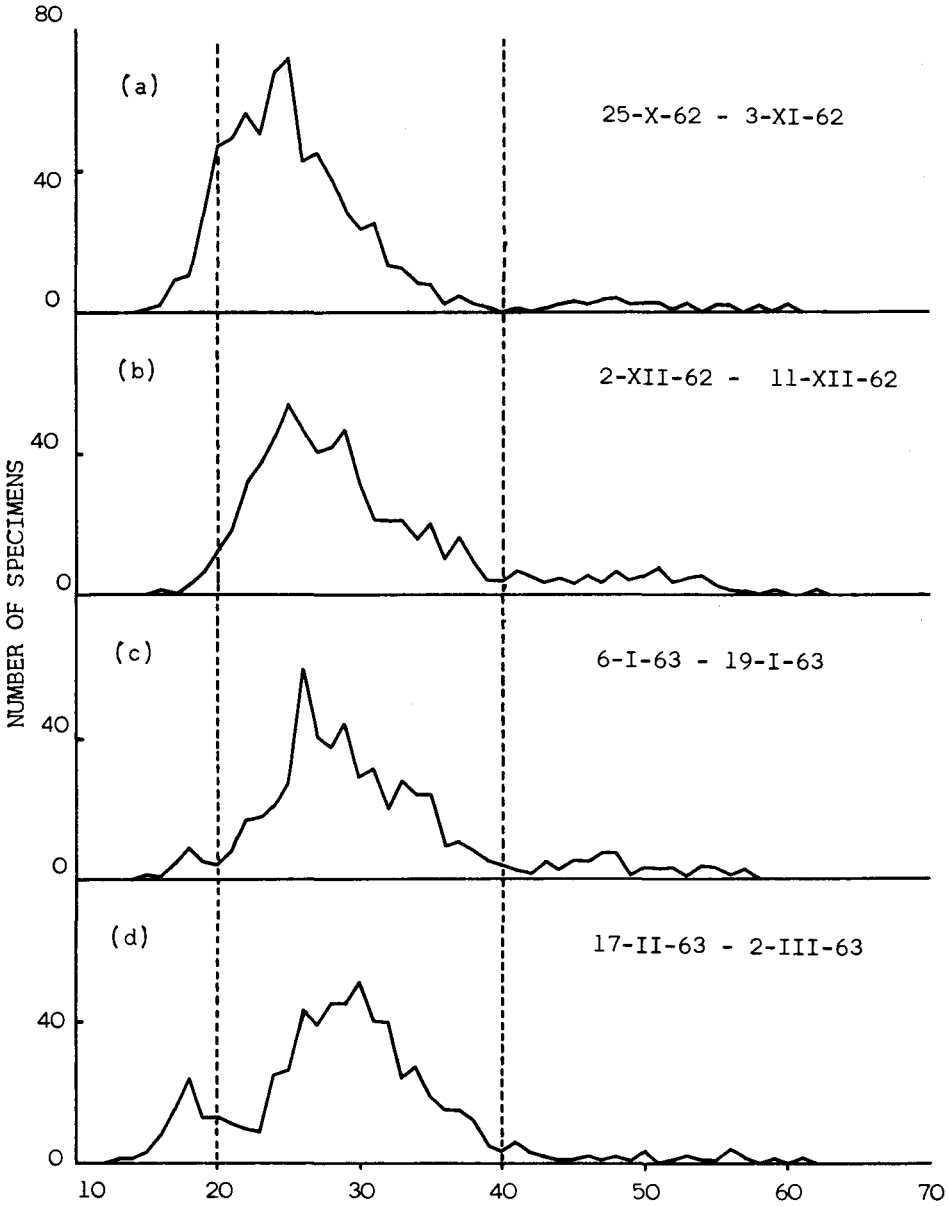
80
40
0
(a)
25-X-62 - 3-XI-62
(b)
2-XII-62 - 11-XII-62
(c)
6-I-63 - 19-I-63
(d)
17-II-63 - 2-III-63
NUMBER OF SPECIMENS
10
20
30
40
50
60
70
Total length in cms.

Fig. 1

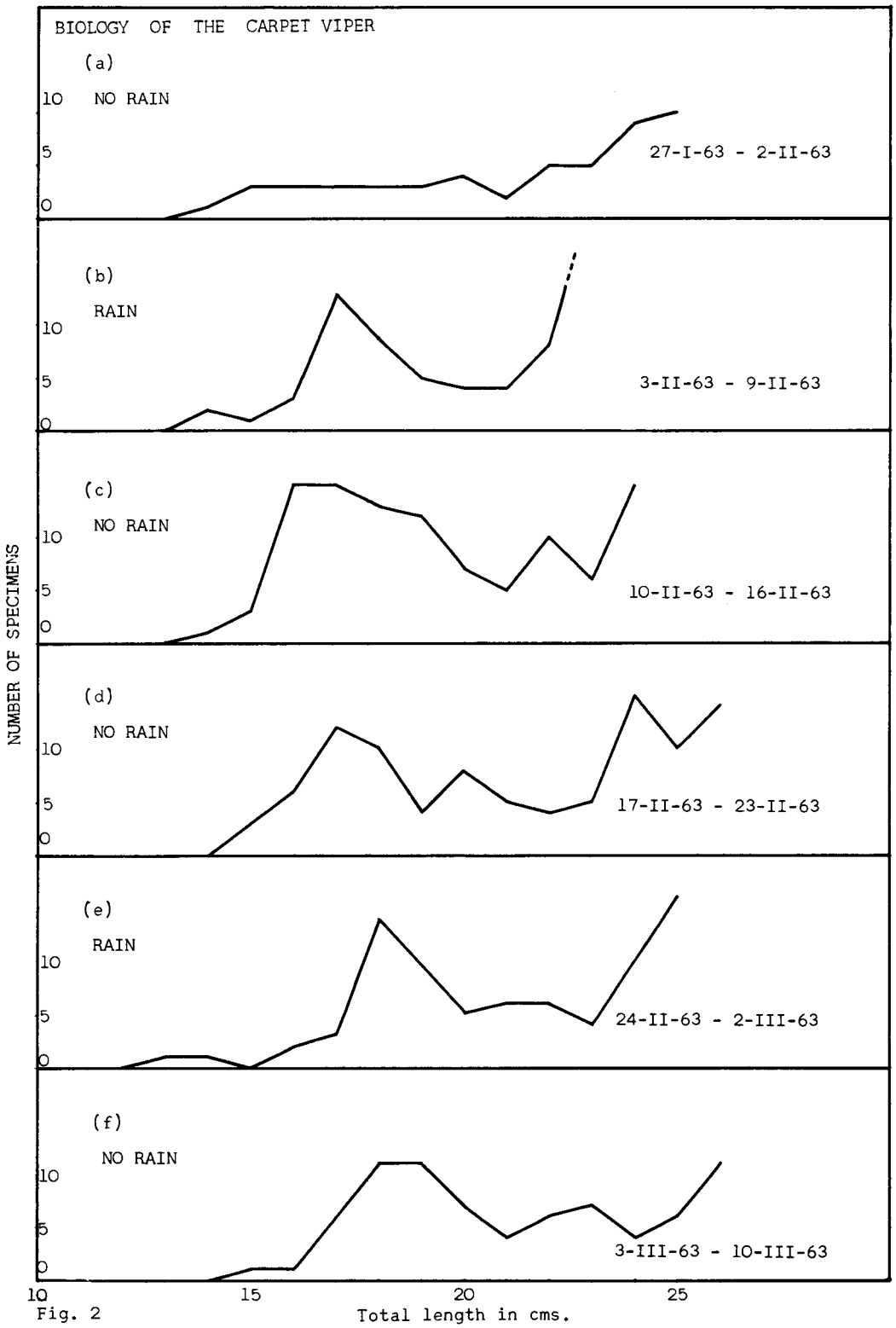
BIOLOGY OF THE CARPET VIPER
(a)
NO RAIN
27-I-63 - 2-II-63
(b)
RAIN
3-II-63 - 9-II-63
(c)
NO RAIN
10-II-63 - 16-II-63
(d)
NO RAIN
17-II-63 - 23-II-63
(e)
RAIN
24-II-63 - 2-III-63
(f)
NO RAIN
3-III-63 - 10-III-63
NUMBER OF SPECIMENS
0
5
10
10
15
20
25
Total length in cms.

Fig. 2

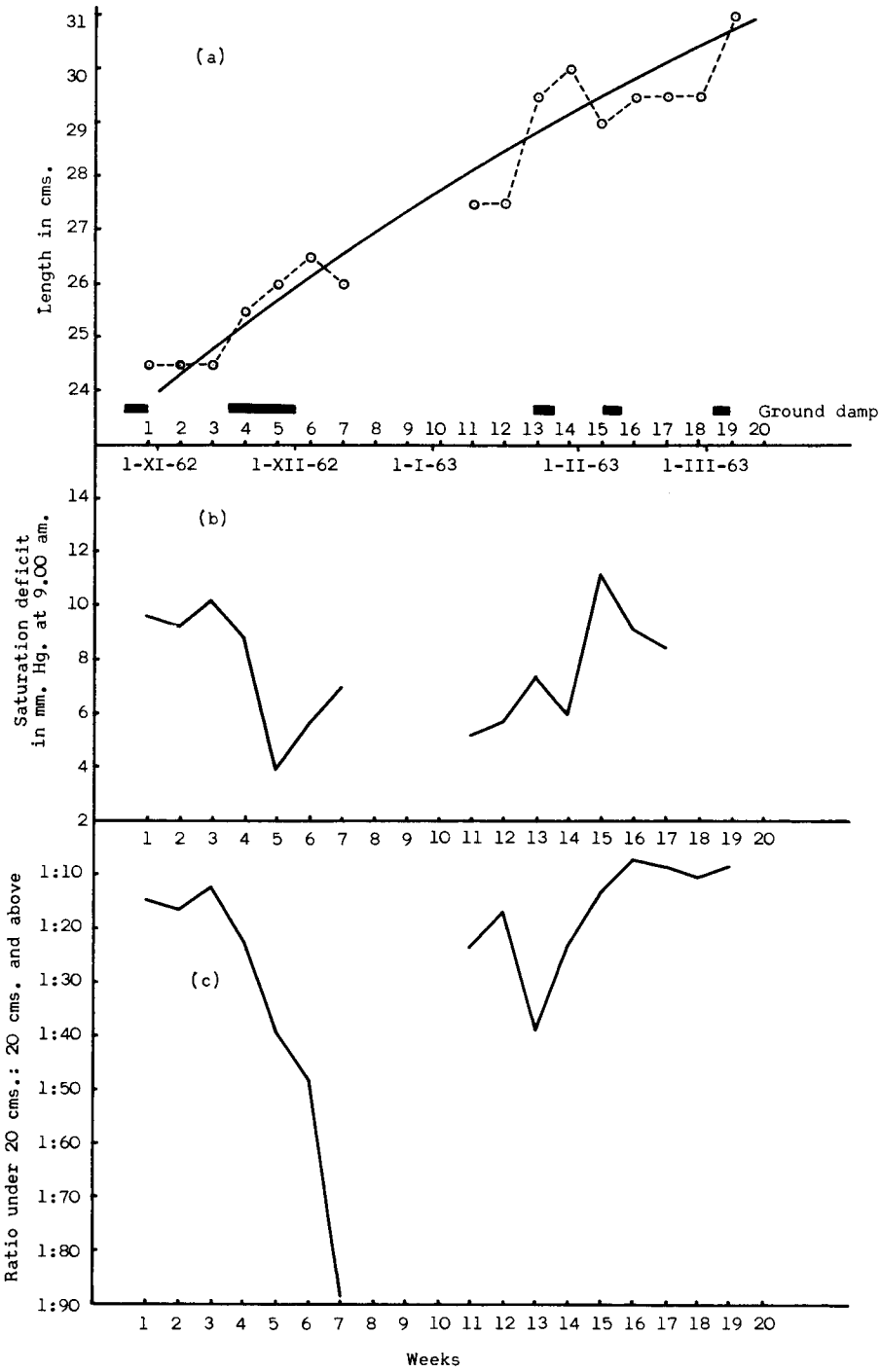
(a)
Length in cms.
31
30
29
28
27
26
25
24
Ground damp
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
1-XI-62
1-XII-62
1-I-63
1-II-63
1-III-63
(b)
Saturation deficit in mm. Hg. at 9.00 am.
14
12
10
8
6
4
2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
(c)
Ratio under 20 cms.: 20 cms. and above
1:10
1:20
1:30
1:40
1:50
1:60
1:70
1:80
1:90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Weeks

Fig. 3

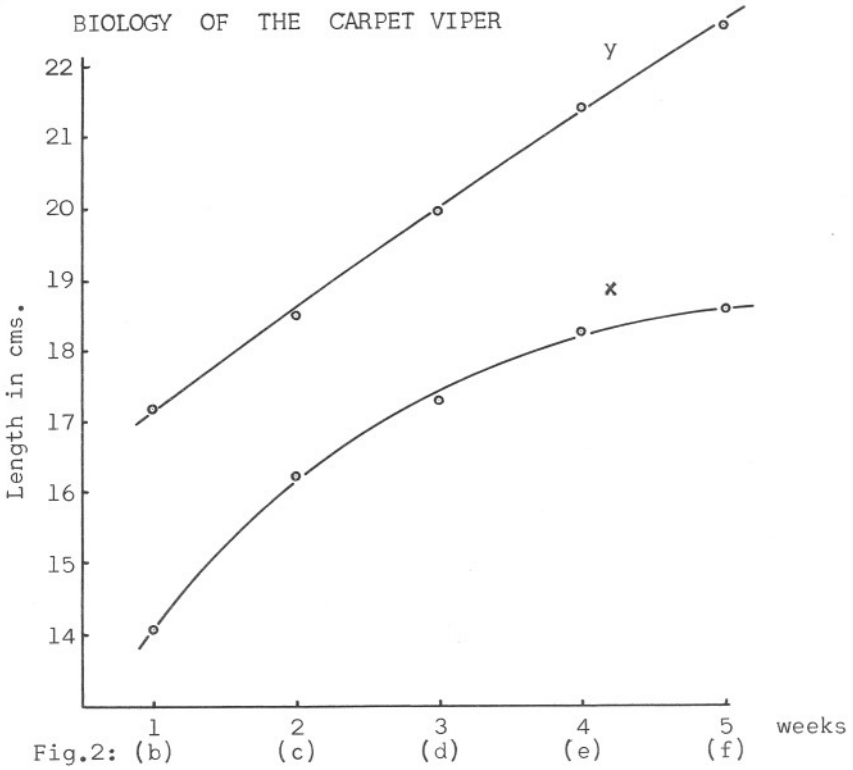

Fig.2:

Fig.4

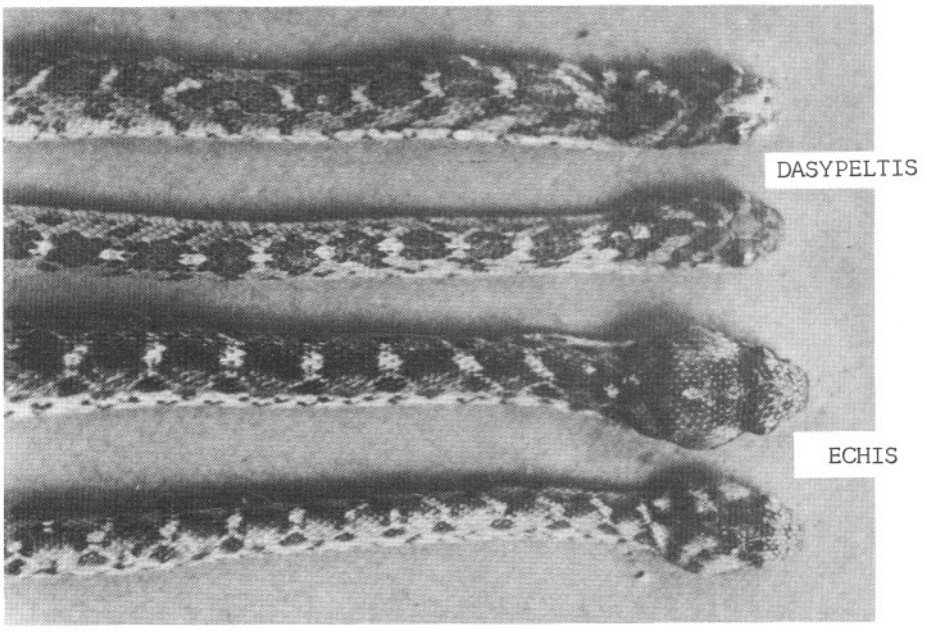

Fig.5

Echis and mimics (Dasypeltis)