Transmission is sporadic with apparently more cases occurring during and immediately following wet years than in drought years (pers. obs.). The areas where transmission occurs lie between 900 and 1800 metres above sea-level and experience summer rains (January to March). The majority of cases fall within the 100 and 350mm isohyets [Fig. 138]. The area is classified as warm desert (Barnard, 1965), where evaporation exceeds precipitation and the annual average temperature is greater than 18°C. Vegetation is composed of grasses and xerophytic plants interspersed with scrub-bush (*Cataphractus*, *Rhigozum*, *Boscia*, *Maytenus* and *Acacia* being the dominant species).

5.2 Man.

The population of Namibia is 1,039,800 (May 1981) of which approximately half live in Owambo and Kavango in the far north of the territory. The southern part, where the majority of cases have been reported, is the least populated part of the country. Most cases diagnosed have been in White (Caucasian) people. It has been suggested (Grové, 1978) that people of Black and Coloured ethnic groups are less liable to infection than are Whites. The former mostly sleep inside where woodsmoke from fires for cooking may repel insects. Whites often sleep outside or with windows wide open on
hot summer nights. Some patients lived close to defined rock hyrax biotope, others often camped out at night near or under cliff shelters when out hunting. The only recorded case of CL in a Black man, an Owanbo (Grove, 1974), was probably not contracted in Ovamboland. He was employed as a farm-hand on the farm "Marmor" near Usakos to the east of Swakopmund in central west SWA/Namibia, and it is here that he may have acquired CL. The biotope here is similar to that from which other cases were acquired.

5.3 Vertebrate hosts.

Two species of rock hyrax occur within the transmission focus. They are allopatric with Procavia welwitschii distributed to the north and north east of the range of Procavia capensis. Their distribution is shown [Fig. 138] primarily to indicate the extent of suitable habitat preferred by the sandfly vector, P. roHL species B. The isolation of Leishmania from nose tissue cultures of Procavia capensis (Grove & Ledger, 1975) prompted the early supposition that the vertebrate host animal had been identified (Grove, 1978). However these hyrax isolates are isoenzymatically very different from those isolated from man and sandfly (Chance et al., 1978). The apparent habitat preference of the sandfly vector has
restricted the search for vertebrate host animals to those that occur within the habitat preferred by rock hyrax. There are many rodent species near the preferred biotope, few have been examined and none have, as yet, been incriminated.

5.4 Sandfly vector.

As previously stated, the sandfly Phlebotomus (Svphlebotomus) rossi species B is the probable vector of CL in SWA/Namibia. This species appears to associate exclusively with rock hyrax and appears to exist within the rocky warrens wherever there is suitable microhabitat.

5.5 ASPECTS OF THE BIOLOGY AND BIONOMICS OF THE SANDFLY VECTOR.

5.5.1. Introduction.

The data presented here were collected at Hardap dam during the periods 19 March to 15 April 1980, 6 March to 26 April 1981 and 14 March to 22 March 1982. Hardap dam (24°29' S; 17°52'E; alt.1150 m) is 240km south of Windhoek and is the largest artificial reservoir in SWA/Namibia. It dams the Fish river 20km north west of the town of Mariental. The habitat is semi-arid

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grassveld interspersed with scrub bush. Small flat-topped hills and rocky outcrops with precipitous sides, hereafter termed mesas, provide ideal habitats for rock hyrax which inhabit the shallow rock faces encircling the tops of these hills (Fig. 139). A plateau escarpment forms the northern shoreside of the dam. It is steep sided with vertical irregular rock faces providing ideal habitats for rock hyrax. A tourist recreation resort, run by the department of Agriculture and Nature Conservation is situated on top of the plateau close to rock hyrax habitats. Infected P. rossii species B have been collected from mesas close to the recreation area used by visitors for camping and watersports.

5.5.2. Materials and Methods.

Sandflies were collected as described in Chapter 2. Traps were visited irregularly throughout the night. Numbers of sandflies caught at these times were noted, as were temperature and wind direction. Wind invariably blew off the water of the dam making the plateau escarpment habitat of the northern shore unsuitable for trapping. Mesa's, sheltered from onshore winds, and those away from the shore proved more productive and greater numbers of sandflies were collected. Maximum-minimum thermometers were located at each light trap.
Fig. 139. Mesa's at Hardap dam.
site. Other weather information was extracted from data supplied by the Hardap weather station, situated about 10 km downstream from the collecting sites.

5.5.3. Dispersal parameters. (as determined by numbers of sandflies in traps).

Strong winds were an important dispersal deterrent. Southerly winds were cold, inducing rapid temperature changes. Warmer, light winds from the north east and north west did not noticeably affect dispersal. If there was a wind it invariably died down a few hours after sunset. Rain, depending on the time of day it occurred, had a delaying effect on sandfly dispersal. Rainfall, when it occurred was usually in the late afternoon. This tended to lower the temperature such that by sunset the temperature was below the optimum. Therefore, although the humidity was increased, temperature was the limiting factor in this instance. Rainfall during the night also inhibited sandfly dispersal. However, by the evening of the next day, providing no rain had fallen late in the day, optimum humidity and temperature conditions existed for increased sandfly dispersal. Humidities below 35%-45% RH (dusk to dawn) outside the preferred microhabitat appear to inhibit the dispersal of sandflies. Temperature was the all important factor determining
Fig. 140. Number of *P. rossi* species B (♀♀ & ♂♂) caught and prevailing weather conditions at the time.
sandfly dispersal [Fig. 140]. At the study area daily maximum and minimum temperature varied greatly from day to day. Periodic visits to light traps during the night indicated that optimum dispersal time was from sunset to 23h00, providing that air movements were minimal. The temperature during this time varied between 19° and 24°C. It was further noted that on very hot nights, no dispersal occurred until the temperature dropped below 25°C which was usually much later (±24h00). Once the sunset temperature dropped below 15°-18°C very few sandflies were caught, and by the end of April it became too cold and sandfly activity outside the warrens came to a virtual halt. No correlation between changes in atmospheric pressure and sandfly activity were evident (as suggested by Killick-Kendrick et al., 1984 for Phlebotomus ariasi in France).

In summary then, the optimum temperature range for the dispersal of P. rossi species B from its microhabitat lies between 19° and 24°C. Very little dispersal occurs after late afternoon rains because of a drop in temperature. Strong southerly winds are disadvantageous. Very few sandflies were collected when the humidity (outside) was less than 45% RH. Increased humidity is advantageous for dispersal, providing that the ambient temperature is within the suggested optimum range.
Factors affecting the infection rate.

The total rainfall for January to April (rainy season) of 1981 was severely reduced (22.8 mm) compared to the same period during 1980 (167.9 mm). No Leishmania were isolated from *P. rossi* species B during the 1981 period as opposed to 6 isolations in 1980 [Table 4].

**TABLE 4. Infection rates of female *P. rossi* species B dissected during 1980 and 1981**

<table>
<thead>
<tr>
<th>Date</th>
<th>At light</th>
<th>Oiled cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980 (20 nights)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. dissected</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>No. positive</td>
<td>5 (31%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>1981 (50 nights)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. dissected</td>
<td>168</td>
<td>44</td>
</tr>
<tr>
<td>No. positive</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*proportionally more sandflies were collected during 1981 than 1980, possibly as more light traps were used.*
This may have been for a number of reasons. During periods of drought as in 1981, very little vegetation was evident and under these circumstances the potential vertebrate host numbers can be assumed to be reduced. Necessity would force survivors to move considerable distances to "greener pastures". As collecting was carried out in the same localities during all years, the vertebrate hosts may have moved, or perhaps they only existed in very low numbers. For example, both these factors seemed to be the case with rock hyrax in these collecting localities. This may be one of the reasons why such a high percentage of infected flies was found during 1980 as opposed to 1981. Possibly during 1981 an alternative bloodmeal source was not capable of sustaining a Leishmania infection; another reason may be the age composition of the sandflies sampled.

5.5.5 Age composition.

The age composition of a vector population is important. The more old individuals that are present in a population, the more effective it will be as a vector species. The more bloodmeals an individual takes the more likelihood there is that it will become infected.

The physiological age of an individual is assessed by
examining its ovaries. A few specimens kept and fed under laboratory conditions matured egg batches after a bloodmeal.

It is thus assumed that *P. rossi* species B is gonotrophically concordant (see Detinova, 1962: 14, "All members of the blood sucking Diptera ... and *Phlebotomus* are characterised by gonotrophic concordance"). The method employed was that used on mosquitoes by Gillies and Wilkes (1965), and first developed by Polovodova (1949), i.e. the examination of the ovarioles for follicular dilatations. It has subsequently been shown by Guilvard *et al.* (1980) and Wilkes and Rioux (1980), who examined the Mediterranean phlebotomine species *Phlebotomus ariasi* (Tonnoir, 1921) and *P. mascitti* (Crassi, 1907), that it can be successfully applied to phlebotomines.

Two hundred and fifty *P. rossi* species B were dissected and of these 166 were age-graded, the remainder were unreadable either because the specimen had been dead for some hours and decomposition had started or because of initial inexperience in the technique used. Most specimens of *P. rossi* species B caught during 1981 were nulliparous, i.e. had never taken a bloodmeal and were therefore very young (Fig. 141). Parous ovaries other than unipars were not seen.
Fig. 141. Age composition of the P. rossi species B population caught at light during the 1981 study period.