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The caves of Barrow Island and their fauna

A Report to West Australian Petroleum Pty Ltd.

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Abstract

In addition to a diverse assemblage of land mammals, Barrow Island is now known to be home to an endemic and highly adapted cave fauna of great antiquity but clearly related to the Cape Range troglobitic fauna. This finding is the result of a short field trip in September 1991 to survey for troglobitic fauna (obligatory cave inhabiting species).

The troglobites are a micro-whip scorpion (Chelicerata: Schizomida), a false scorpion (Chelicerata: Pseudoscorpionida: Atemnidae), a millipede (Diplopoda: Spirobolida), a wood louse (Crustacea: Isopoda: ?Oniscidae) and a cockroach (Insecta: Blattaria: Nocticolidae). In addition there is a new genus and species of non-troglobitic pill bug (Isopoda: Armadillidae: Buddelundiinae) and a family of Isopoda previously unknown in the Indo-Pacific area (Olibrinidae). A spider belonging to the Cycloctenidae, a family typical of wet forests of eastern Australia and New Zealand, was identified from material previously collected. Many other surface dwelling invertebrates were found previously unrecorded from Barrow Island.

The troglobitic fauna is a living time capsule from days when wet forest covered the area.

Additional work will certainly show that the troglobite community is much more diverse than is currently known. The timing of this research, coupled with manipulations of the caves, will be important to gain the maximum information.

The fauna is out of sight but highly sensitive to environmental change; its incorporation into the environmental management philosophy and practice for Barrow Island should be expedited.

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Introduction

Cape Range on the North West Cape peninsula of Western Australia contains a very rich community of highly adapted troglobites (cave adapted animals usually eyeless, long limbed and without pigment). The affinities of part of the fauna clearly lie with the wet tropical forest leaf litter community of north-east Queensland. As such the occurrence of this fauna is the only evidence that such forest has occupied the area since the Miocene. The peninsula also harbours the entire vertebrate troglobite fauna of Australasia in the form of two blind fish in the subterranean waters of the coastal limestone (Humphreys 1991a,b; Humphreys & Adams 1991), as well a both marine and freshwater troglobitic crustacea.

To the west of Cape Range the continental shelf is at the closest point in Australia to the current land area but to the north and east lies the extensive North West Shelf. This shelf would have been widely exposed in the Holocene and totally exposed at times during the Quaternary. Cape Range is currently isolated from two 'islands' of Cape Range Formation , namely Rough Range to the south-east and Barrow Island to the north-east. The isolation to the south is by hypersaline ground water below aeolian sands and in other directions by the marine inundation of the North West Shelf.

The most likely place to find a fauna similar to that on Cape Range is on Barrow Island which lies 160 km to the north-east of North West Cape. Part of Barrow Island is covered by thin Quaternary deposits but elsewhere there are exposures of 'Trealla Limestone', the limestone that overlies the highly cavernous Tulki Limestone in Cape Range which contains the rich troglobite fauna. However, while the 'Trealla Limestone' on Barrow Island is the same age as the Trealla Limestone in Cape Range it is a new formation (J.K. McNamara and G.W. Kendrick, pers. comm. 1991) that is lithologically similar to the Tulki Limestone in Cape Range. Barrow Island rises to 65 m so that there is plenty of altitude for significant cave development above the present water table.

Aims

1. To determine whether elements of the Cape Range troglobite fauna occur in known caves on Barrow Island and if so to sample and describe that fauna.

2. Search exposures of the 'Trealla' Limestone for new caves to determine the extent of cave adaptation and the affinities of the fauna.

Definitions

The fauna found in caves is traditionally divided amongst:- accidentals (species entering caves by chance); trogloxenes (sporadic cave dwelling species e.g. bats); troglophiles (facultative cave dwelling species, often divided into first level troglophiles, found both in cave and epigean habitats, and second level troglophiles which are found only in caves) and troglobites (obligate cave dwellings species usually with significant eye and pigment reduction and which are of considerable evolutionary interest; Hamilton-Smith 1967; Culver 1982). Various other terms and categories are used by different workers (e.g. Vandel 1965).

These categories are based on the level of dependence on the cave system (Hamilton-Smith 1971) deduced from their distribution within and without caves and the degree of morphological adaptation presumed to be adaptive to cave life. Second level troglophiles may turn out to have clear adaptations to caves in non-morphological characters, e.g. physiological (Barr 1963, H. Dalens, pers. comm. 1988). As these are, in essence, functional definitions the classification requires assumptions about the nature of the adaptation or detailed knowledge of the species biology for allocation between these categories to be made. This knowledge is unavailable for virtually all the Australian cave faunae, especially the newly worked areas such as Cape Range and Barrow Island.

For the most part species from Barrow Island are categorised in these terms only if a specialist in the group, who is also experienced with cave species, has designated a category, or if they are eyeless or lack pigment in taxa normally possessing these characters. Most species are simply recorded as having been found in caves and are not categorised owing to the lack of information on their biology and that of the epigean community.

Climate

The mean annual rainfall of Barrow Island is 330 mm and falls more predictably than the mean of 284 mm of rain on the North West Cape peninsula. The area is classified as semi-arid but it is situated in that area of Australia with the least predictable rainfall; both the constancy and contingency (*sensu* Colwell 1974) of the rainfall is low and the probability is low of single rainfalls sufficient to flood deeply caves (see full discussion in Humphreys *et al.* 1989).

The vegetation of Barrow Island has closer affinities with the North West Cape peninsula than it does with the adjacent Pilbara coast.

Searching

We examined all caves or potential caves known by those long familiar with the island (W.H. Butler, G. Devenny, D. Goodgame and R. Lagdon). Considerable searching on foot and by helicopter failed to reveal any substantial caves not already known to those familiar with the small (223 km^2) island. In one respect this is unsurprising as the island has been worked by numerous people over >30 years including competent field geologists and naturalists: the intensity of this working is indicated by there being *ca* 10 km of road or seismic track per square kilometer of island, plus numerous pipeline routes that are not coincident with these roads and tracks. In another respect the lack of openings is surprising because drillers familiar with the area repeatedly report hitting cavities between 12-30 m from the surface. While it is known that most cavities in limestone do not have entrances (Curl 1966), the implied high degree of entranceless cavities on Barrow Island itself warrants a study based on the examination of the bore data.

The caves and karst features found are mainly to the central and western side of the island where the relief is greatest. Details of the caves are given in the Karst Index (Appendix 1) and plans of the more significant caves in Appendix 2.

The cave environment

The relict rainforest troglobites of Cape Range are associated with high relative humidity, soil moisture and organic carbon content in the mud-banks but not with cave temperature (Humphreys 1990): a related fauna on Barrow Island could be expected to show similar relationships. The relict rainforest troglobites of Cape Range are found in all caves with >95% RH and below this level the proportion declines of caves with troglobites such that at <80% RH they are absent.

At the time of the visit to Barrow Island (September 1991) the caves were very dry despite reasonable rainfall over the previous few months (Appendix 3); this was the case also in Cape Range during the same period, rainfall having been insufficiently heavy to flood into caves. The cave systems on Barrow Island thus appear to be of the type that receive substantial inputs only after exceptional rainfall (>156 mm in one fall) like some of the Cape Range caves (Humphreys *et al.* 1989). Following such rainfall the caves would be expected to contain the greatest number of troglobitic species and ideally they should be sampled at such time.

The caves on Barrow Island are at the upper extreme of temperature range of the Cape Range caves. The temperature and humidity of cave B1 are fairly uniform throughout, not differing significantly between areas. The mean temperature was 27.6 ^{o}C (s.d. 0.6, n= 11) and the mean relative humidity was >96% throughout, approaching 100% in parts. The lower chamber of B1 containing mud-banks that contained 26.3% water, while the cracking mud higher in the chamber contained 23.1% water (g H2O g^{-1} soil). In Cape Range the relict rainforest troglobites are found in all caves with >27% soil water and below this level the proportion declines of caves with troglobites. The mud away from the water in the upper chamber contained 19% (S.D. 0.7, n=4) water.

The water table is reached in cave B1 and it is saline and exhibits tidal flow: the cave is close to the sea cliffs. After heavy rain a layer of freshwater would be expected to form on the surface of this water; indeed, white 'sand hoppers' have been reported at such times in this cave. In the northern hemisphere such anchialine caves, even on islands, often contain relict higher taxonomic groups which are considered to be "living fossils" (Danielopol 1990; Iliffe *et al.* 1984; Stock 1986; Wilkens *et al.* 1986), especially in the crustacea (Schram 1986). Indeed, one such group of Crustacea has recently been found in anchialine systems on the North West Cape peninsula (W.F. Humphreys, unpublished).

In Cape Range four caves reach a perched water table (fresh water and >100m above sea level) and they all contain an amphipod which is probably of marine origin and part of the *Victoriapisa* complex (Gammaridae; B. Knott; pers. comm. 1988). The coastal plain surrounding the North West Cape peninsula contain a number of crustacea including troglobitic shrimps and amphipods (Humphreys & Adams 1991; W.F. Humphreys, unpublished data).

Cave B2 is a horizontal cave which passes through a headland and contains an extensive warren of *Bettongia lesueur* (Marsupialia). The environmental conditions inside the cave did not differ greatly from those outside (inside 24.3^{o}C and 69% RH) at the season of measurement.

There are rock clefts on Barrow Island from which warm and humid air is blowing (e.g. B6) and such clefts clearly communicate with much larger humid caverns where troglobitic fauna may be expected.

Tropical winter

The net movement of water between caves and the outside is determined by the gradient in partial pressure of water vapour (Edney 1977). Barrow Island lies just within the world climatic area in which the average daily range in temperature exceeds the average monthly range (Petterssen 1958). Hence on Barrow Island, as in many tropical areas (Howarth 1980), the night time temperatures often fall below the cave temperatures; this results in a net movement of water vapour out of the cave at night (tropical caves containing troglobites usually have R.H. close to 100%). This has been termed the 'tropical winter effect' (Howarth 1980, 1983) by analogy with the excessive drying of caves in colder climates in winter. Hence, all else being equal, warm caves will dry more rapidly and have shorter periods when they are suitable for troglobite species in the caves of Barrow Island.

There is a marked tropical winter effect on Barrow Island, hence the caves have a strong outflow of water down the gradient in water vapour pressure (Appendix 3). The humidity in the depth of even the 'dry' caves is about 20-30% points greater than that of the surface (Appendix 3) even at a time when the caves are relatively dry. Hence, there is clearly a good buffering effect (capacitance) from stored water, either from a pool, as in B1, or from water stored in mud-banks (an important store of water in Cape Range). Those caves which take the form of a blocked sink hole (B3 & B10) clearly must extend down to a water store of some sort.

Caves on Barrow Island have deep temperatures differing by 5.6°K (23.7-29.3°C). Hence, because the cave atmospheres are almost saturated with water vapour, there will be about a 30% difference in the water vapour pressure within the moist caves. Therefore under the same outside conditions some caves will have gradients in water vapour pressure which are the reverse of others. More detailed and long term recording would be required to determine these conditions.

The outflow of moist air, resulting from the unstable thermal stratification in these caves or from barometric changes, may result in the condensation of water in the upper reaches of a cave or at the entrance. For example the condensation point is *ca* 27°C for deep air from B1 and *ca* 24°C from B10 (see Appendix 3). This effect permits the presence of the schizomids in the uppermost, and otherwise dry, part of cave B1.

Fauna

Humid caves (Appendix 4)

A Cape Range-style troglobite fauna was found in only one cave (B1, Ledge Cave). It comprises a micro-whip scorpion *Draculoides* sp. nov. (Chelicerata: Schizomida), a blind highly cave adapted cockroach, *Nocticola* sp. (nr *flabella* Roth 1991: Blattodea), and a species of troglobitic Isopod, of unknown family. In addition there is a troglobitic millipede belonging to a different Order (Spirobolida) from the highly troglobitic millipedes of Cape Range (W.F. Humphreys & W. A. Shear, unpublished; W. A. Shear, unpublished). It also contains the epigean but humid adapted terrestrial Philosciid Isopod (*Laevophiloscia yalgoonensis*), as did the dry cave (B3) after it was reactivated by adding water and organic matter; this species is found also in Cape Range caves where they are an important food source for some troglobites (Humphreys *et al.* 1989).

The schizomid adds a second species to the previously monospecific genus *Draculoides*, the only troglobitic genus of schizomids in Australia (Harvey in press b). Schizomida are a tropical group which are frequently found in caves elsewhere in the world. Cave faunae generally, and schizomids in particular, are vulnerable to change in the water table. *Schizomus wessoni* (Chamberlin) was eliminated from its type locality as a result of long term drying of the Santa Cruz River due to agricultural activities, and oases were rendered unsuitable for *S. joshuensis* by draining (Rowland and Reddell 1981).

The cockroach *Nocticola flabella* is the only described member of the genus that is troglobitic and the Barrow Island population represents a second troglobitic species of this very highly adapted troglobite. There are three species of *Nocticola* in north-east Queensland.

This fauna has clear and close affinities with that found in Cape Range. Because it covers the entire range of troglobites, from the environmentally relatively resilient schizomids to the most sensitive *Nocticola*, I would expect that Barrow Island contains a much richer troglobitic fauna than has yet been sampled.

All the schizomids were found within a 0.5 m^{-2} area in the upper part of the top chamber on a dry surface but where the relative humidity was high (>96%); in Cape Range it has been found that the troglobites will travel through dry areas if the relative humidity is high enough and may thus approach cave entrances. The *Nocticola* sp. were taken in the lower 'mud-chamber' on the mid-level mud-banks where the humidity is high and the soil water content was between 23-26%; the millipedes were also taken in this location.

Dry caves (Appendix 4)

The dry caves (B2 & B3) contained an undescribed genus and species of pillbugs (Isopoda: Armadillidae: Buddelundiinae; H. Dalens, pers. comm. 1991) that shows no morphological adaptations to cave life. Cape Range contains a diverse endemic fauna of both armadillid and philosciid isopods, mostly epigean species although some clearly dependent on humid conditions. Philosciid Isopod (*Laevophiloscia yalgoonensis*) was found in cave B3 after it was reactivated by adding water and organic matter.

Predatory bugs (Hemiptera: Reduviidae) of two species were found in the dry caves (B3, B4, B5 & B8). Both are clearly related to those found in Cape Range .

The pseudoscorpion, *Oratemnus* sp. nov. (Pseudoscorpionida: Atemnidae) found in a dry cave (B5) has clear cave adaptation (M.S. Harvey, pers. comm. 1991) in that it is slightly built for its family. It is, nonetheless, massively sclerotised and heavily built compared with the troglobitic pseudoscorpions from the humid caves of Cape Range (Harvey, in press a, c) which have no elements in common with the epigean pseudoscorpions, even at the family level. The genus is widespread in Australia and includes species from caves.

A juvenile Cycloctenid spider was collected from B2 in 1976 by D. Lowry and is the first record of this family in Western Australia. It is typically a family of humid forests of temperate to tropical eastern Australia and New Zealand and it has only recently been found in such habitats in the south west of Western Australia (M.S. Harvey, pers. comm. 1990). It presence in B2 is somewhat surprising as the cave at present is very dry.

Manipulations

Evidence from Cape Range shows that the caves receive, from periodic but unpredictable heavy rainfall, the influx of water and organic matter needed to fuel the cave community. The water and organic carbon content of the caves then declines until the next influx of water and its contained organic matter. Should either the water or organic carbon content of the cave fall below some threshold level then the troglobites disappear from the cave but can be induced to return over a period of many weeks by replenishing the supply of water and organic carbon (Humphreys *et al.* 1989, Humphreys 1991b).

Ledge Cave (B1) was clearly low in organic material although the relative humidity and the water content of the mud-banks is sufficiently high to support troglobites. Cave B3 (a sinkhole) was clearly too dry and lacked a base of organic matter. To encourage any troglobitic fauna to enter the caves from the crevices (Humphreys 1991b) water and organic matter (leaf litter) was added to B3 and organic matter alone added to two levels in B1.

The relative humidity at the bottom of cave B3 rose from 69% before the addition of water to 84% and thereafter fell to 79% RH eight days later. Both manipulations worked as expected, attracting in numbers to the moist litter within the first week the humid adapted but non-troglobitic isopod *Laevophiloscia yalgoonensis* not previously present in the area. This is as predicted from experimental work in Cape Range (Humphreys 1991b). Unfortunately the field work ended then but the manipulation in B1 should attract other troglobitic species over the following weeks. The manipulation in B3 will not attract much else as it was already rapidly drying at the end of the field trip and water would need to be added regularly to maintain the humidity level in that cave. Only one other cave (B10) on Barrow Island would seem worthy of similar treatment.

Waste disposal

The Treatment Process: the schematic study of water production and dispersal (Fig. 13 chart A57691) has excess water being returned to limestone caverns at 50-80m (i.e. below the water table). In practice excess water from a southern separator plant was being disposed of into a cave (B7) of unknown but clearly significant extent and so enters the superficial karst system. Another cave (B6) has apparently been used for the same purpose. Such planned disposal is in addition to that resulting from the accidental spillages of both oil and salt water, mainly the result of pipe fractures.

As the water is saline disposal in this manner in B7 would be undesirable even if it did not include substantial amounts of oil. Petroleum can move large distances in fractured limestone (Wilber 1969) and the oil will eliminate any cave fauna wherever it spreads in the karst system. Monitoring the water from adjacent bores is unlikely to provide information on the spread of oil on the water surface and hence potential damage to the fauna.

A thin layer of light oil on an exposed water surface is highly visible but is rapidly lost through both evaporation, photic and microbial action. Oil entering karst systems, while being invisible, is persistent (*New Scientist* No. 1786: 22-26 [1991]) as there is no photic and little microbial action and, as it evaporates in confined spaces, it may accumulate to toxic levels in the caverns. Hence, waste water unfit for disposal in the sea is definitely unfit for disposal into the superficial karst system.

Some cave systems have animals which are halocline specialists which are lost when there is a breakdown of marked salinity stratification such as would result from the disposal of saline waste water into the superficial karst. In consequence it is undesirable that either pure saline water or oil be disposed of into the superficial karst and the World Conservation Monitoring Centre has warned against such practices (*New Scientist* No. 1794: 6 [1991]).

Prospects

As well as containing a diverse assemblage of land mammals, Barrow Island is now known to be home to an endemic and highly adapted cave fauna of great antiquity but clearly related to the Cape Range fauna. The fauna is a living time capsule from days when wet forest covered the area. It will certainly be much richer than is currently known and a series of brief but regular research trips would be required to establish and monitor manipulations of the three suitable caves to determine the richness of the cave fauna. This would be desirable because the cave fauna is highly vulnerable to changes in both the aquatic and aerial component of cave environments. Such trips would need to be timed to coincide with the natural expansion of the fauna to be expected following exceptional rainfall on Barrow Island.

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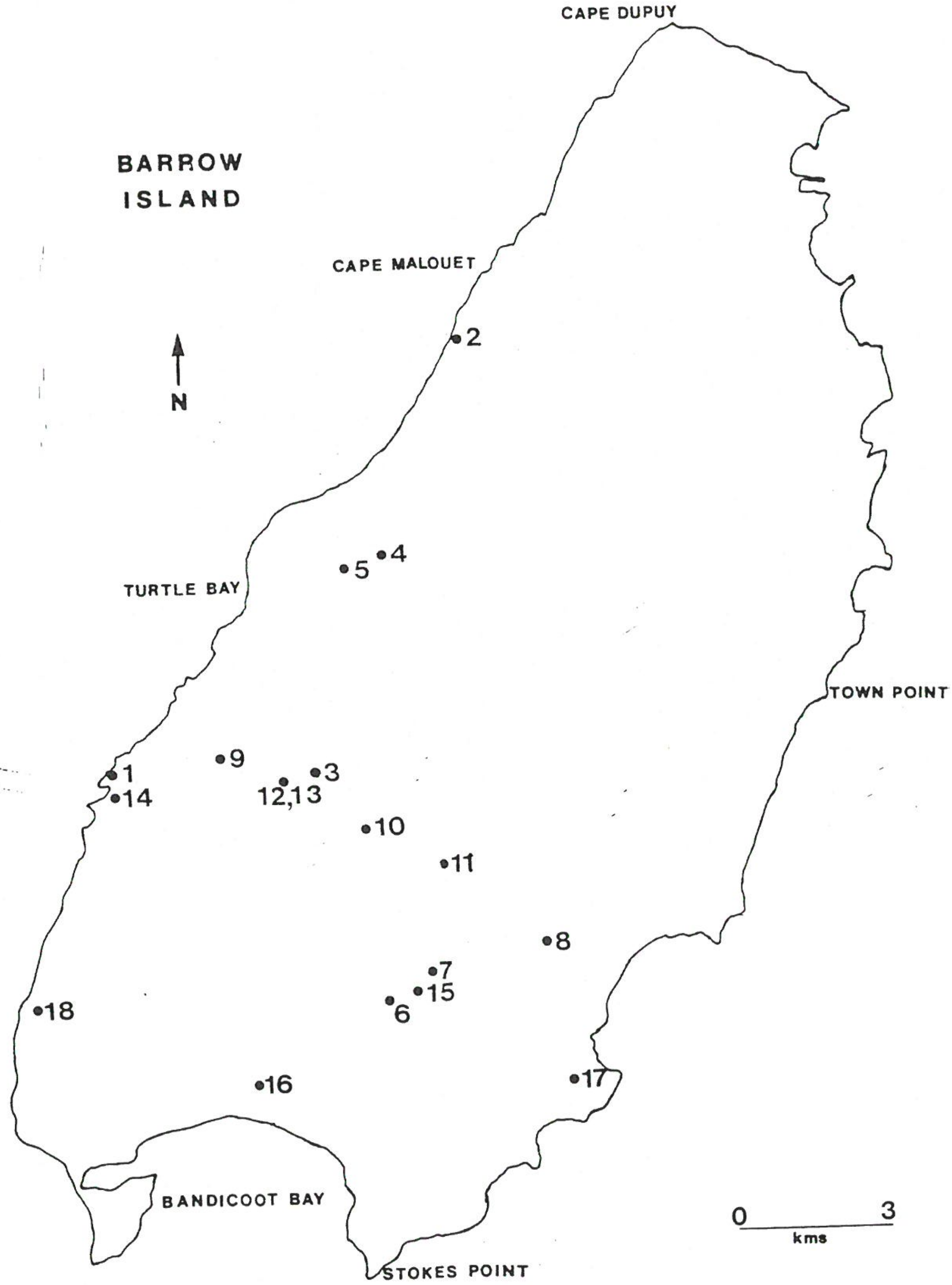
Appendices

Appendix 1: Karst Index for Barrow Island, Western Australia.

Map of Barrow Island showing the locations of the 18 features referred to in the karst index.



B1 - Ledge Cave.
1:50,000 Barrow Island GR 258988 WAPET Block J15.
Collapse entrance to large main chamber with a lot of decoration and breakdown. There are a couple of leads to smaller chambers and a divable sump.
Troglobites have been found in the cave. They include *Draculoides* sp. nov. (Schizomida), *Nocticola* sp. nov. (Blattodea) and an isopod.
20° 48' 09"S: 115°19' 36"E.
First reported by P. Mulholland.

B2 - 'Y'Block Cave.
1:50,000 Cape Dupuy GR 327077 WAPET Block Y32.
A big cave with two entrances just below the top of the cliff. There is some old decoration. Care should be taken when walking through the boodie warren which takes up a large part of the cave floor.
The cave is used by bats.
20° 43' 21"S: 115°23' 34"E.
First reported by W.H. Butler & R. Lagdon.

B3 - 'E' Station Cave.
1:50,000 Barrow Island GR 294989 WAPET Block K17.
Solution pipe 24m deep. A free climb to the top of an 18m pitch at a depth of 6m. There are two good anchor points at the pitch head which gives a clear hang for the rope. No horizontal extension.
Spiders, isopods and tick, ticks, ticks.
20° 48' 08"S: 115° 21' 41"E.
First reported by W.H. Butler & R. Lagdon.

B4 - No name.
1:50,000 Barrow Island GR 310031 WAPET Block S67.
Slot entrance under a fig tree by the side of the road. A passage slopes down for about 8m to a small chamber. Very dry.
20° 45' 50"S: 115° 22' 37"E.
First reported by W.H. Butler & R. Lagdon.

B5 - No name.
1:50,000 Barrow Island GR 303030 WAPET Block S74.
7m wide entrance in the south side of a doline leads into 10m by 13m very dry chamber. Some very low leads on the east side were not explored.
Bats use this cave.
20° 45' 53"S: 115°22' 14"E.
First reported by W.H. Butler & R. Lagdon.

B6 - No name.
1:50,000 Barrow Island GR 316942 WAPET Block F53.
Collapse doline and adjacent slot. Not penetrable beyond daylight. Has been used for the disposal of oily water.
20° 50' 38"S: 115° 22' 54"E.
First reported by W.H. Butler & R. Lagdon.

B7 - No name.
1:50,000 Barrow Island GR 321946 WAPET Block F45.
Pothole in the top of a low hill currently (1991) used for oily water disposal. Very badly polluted.
20° 50' 25"S: 115° 23' 13"E.
First reported by W.F. Humphreys & B. Vine.

B8 - No name.
1:50,000 Barrow Island GR 258988 WAPET Block E22.
This cleft was opened by a bulldozer, it takes drainage, but is not extensive. Very humid.
20° 50' 05"S: 115° 24' 29"E.
First reported by W.H. Butler & R. Lagdon.

B9 - No name.
1:50,000 Barrow Island GR 277990 WAPET Block R82.
Collapse doline with a small cave extending around the west side. Dry.
20° 48' 02"S: 115° 20' 42"E.
First reported by G. Devenney.

B10 - No name.
1:50,000 Barrow Island GR 311977 WAPET Block L42.
Solution pipe descending in a series of pitches to about 30m. Entrance closed by boulder. A lot of old fire extinguishers and other rubbish has been dumped in this cave.
20° 48' 454"S: 115° 22' 39"E.
First reported by G. Devenney.

B11 - No name.
1:50,000 Barrow Island GR 323969 WAPET Block L65.
Blank doline.
20° 49' 11"S: 115° 23' 19"E.
First reported by W.H. Butler & R. Lagdon.

B12 - No name.
1:50,000 Barrow Island GR 291984 WAPET Block K25(E).
Blank doline.
20° 48' 20"S: 115° 21' 29"E.
First reported by W.H. Butler & R. Lagdon.

B13 - No name.
1:50,000 Barrow Island GR 290985 WAPET Block K25(W).
A tiny hole in a small patch of bare rock.
20° 48' 18"S: 115° 21' 26"E.
First reported by B. Vine.

B14 - No name.
1:50,000 Barrow Island GR 261983 WAPET Block J26.
Blank doline.
20° 48' 25"S: 115° 19' 44"E.
First reported by W.H. Butler & R. Lagdon.

B15 - No name.
1:50,000 Barrow Island GR 317943 WAPET Block F44.
Soil filled doline.
20° 50' 34"S: 115° 22' 59"E.
First reported by W.H. Butler & R. Lagdon.

B16 - No name.
1:50,000 Barrow Island GR 286925 WAPET Block B14.
Grike development exposed by bulldozer; takes drainage.
20° 51' 32"S: 115° 21' 09"E.
First reported by W.H. Butler & R. Lagdon.

B17 - No name.
1:50,000 Barrow Island GR 350942 WAPET Block D14.
Small hole in bare rock.
20° 51' 40"S: 115° 24' 29"E.
First reported by W.H. Butler & R. Lagdon.

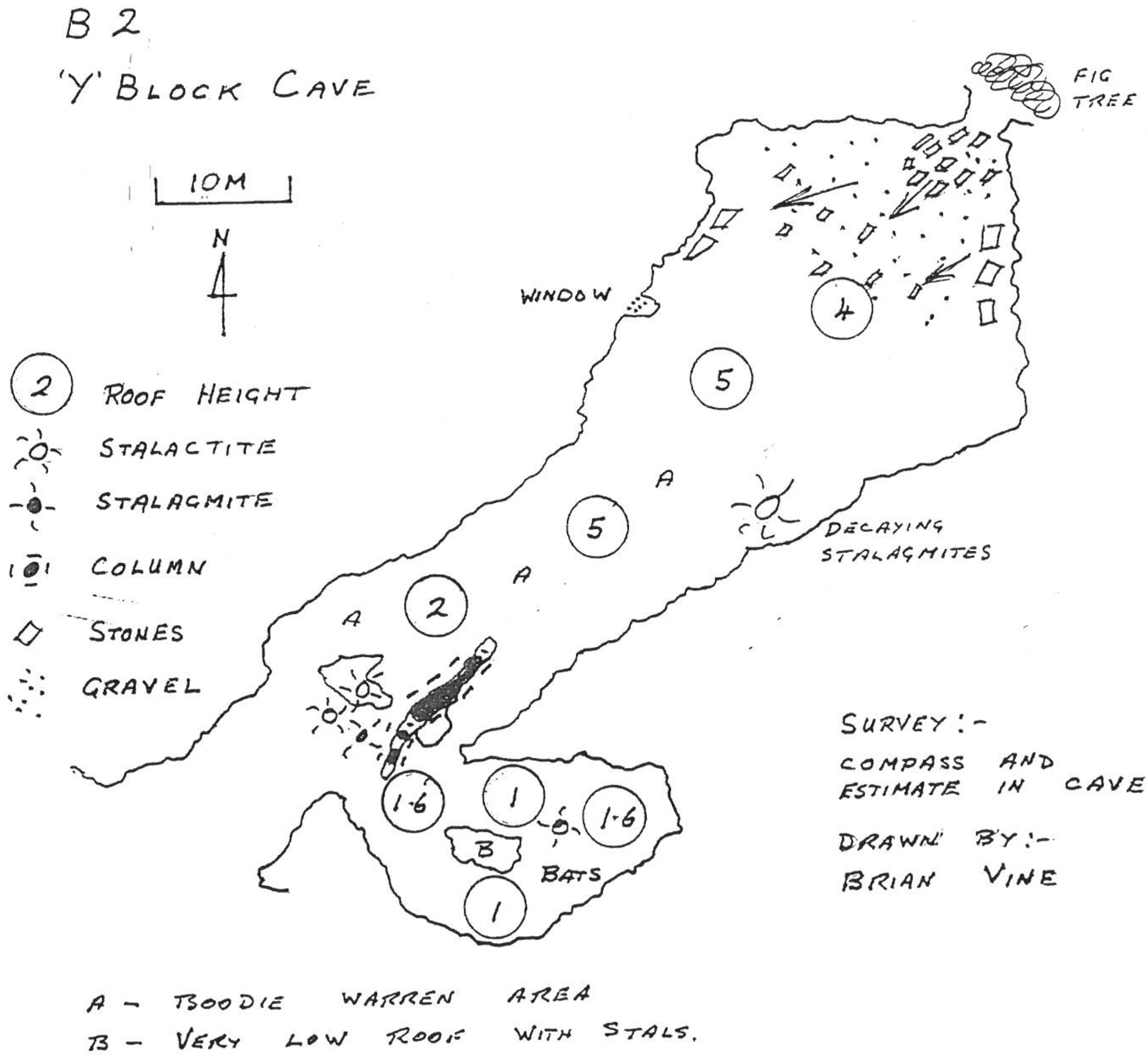
B18 - Chair Hole.
1:50,000 Barrow Island GR 243941 WAPET Block H16.
Brackish water hole in depression; exhibits tidal movement.
20° 50' 40"S: 115° 18' 41"E.
First reported by W.H. Butler & R. Lagdon.

Appendix 2: Plans of the more significant caves on Barrow Island.

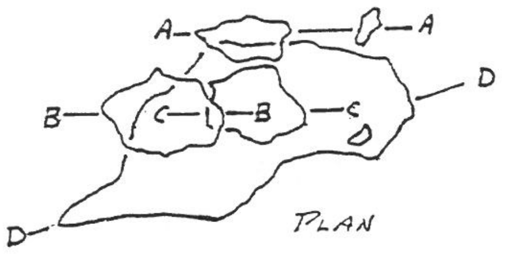
A map of B1 is given in Mulholland (1990).

Mulholland, P. 1990. Ledge Cave - Barrow Island. *The Caver's Chronicle 17*: 5-6.

B2
'Y' Block Cave



B3

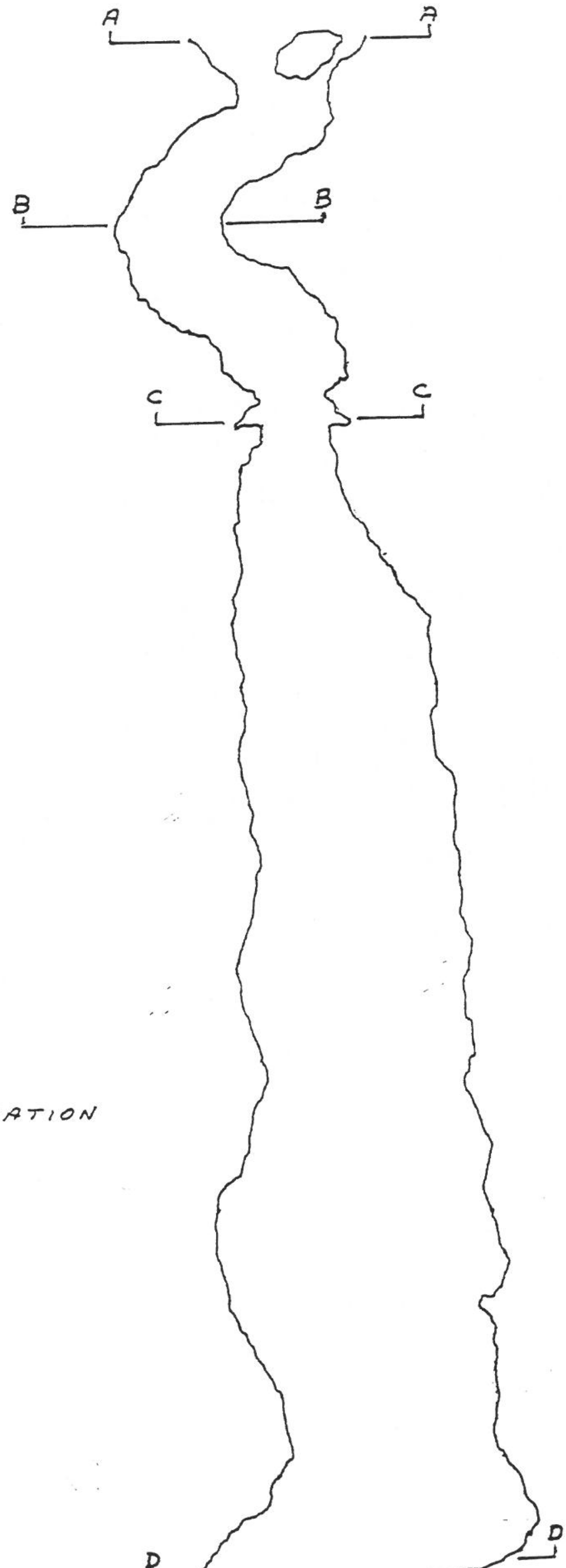


PLAN

1M

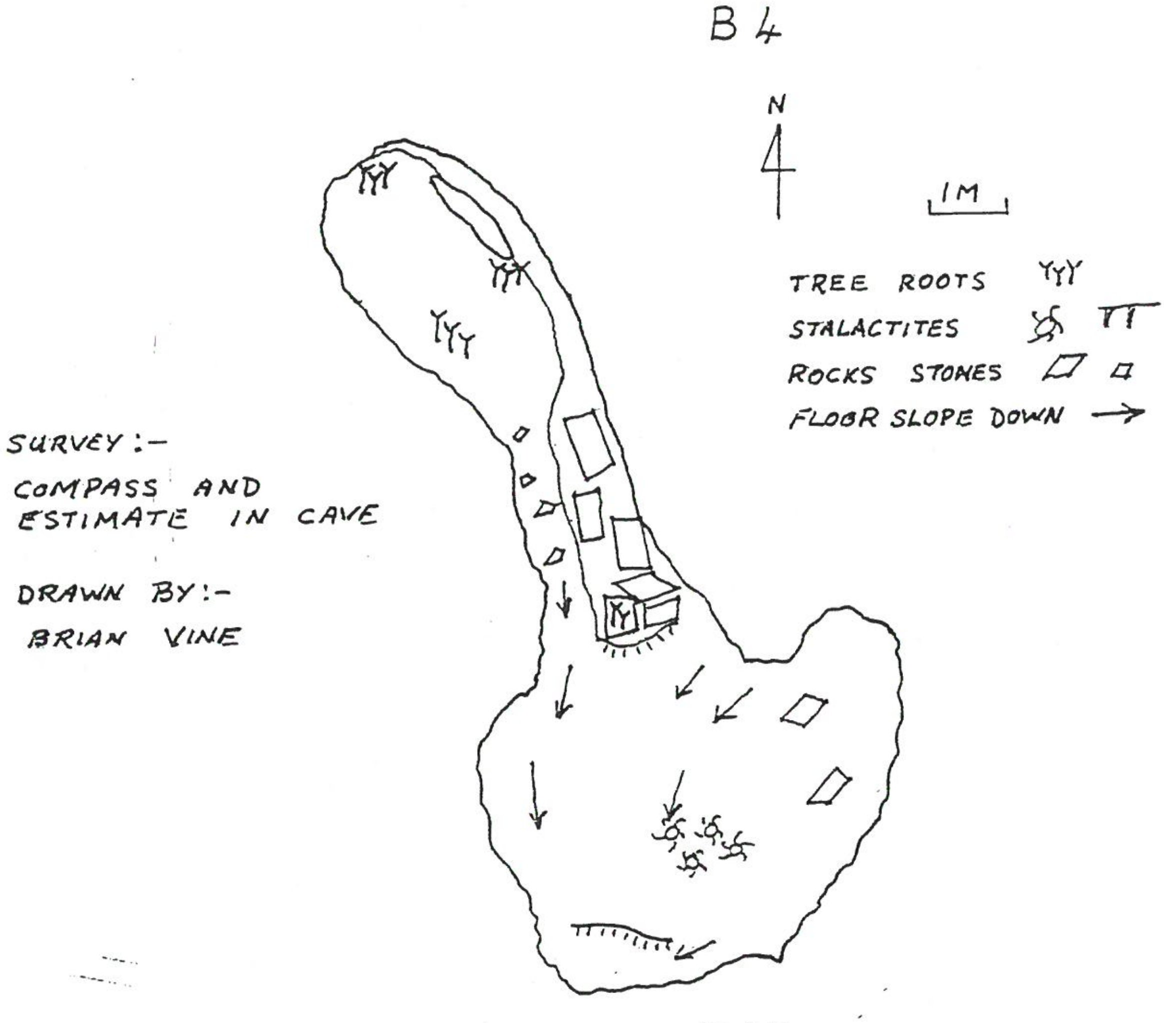
SURVEY:-
ESTIMATED IN CAVE
DRAWN BY:-
BRIAN VINE

'E' STATION CAVE

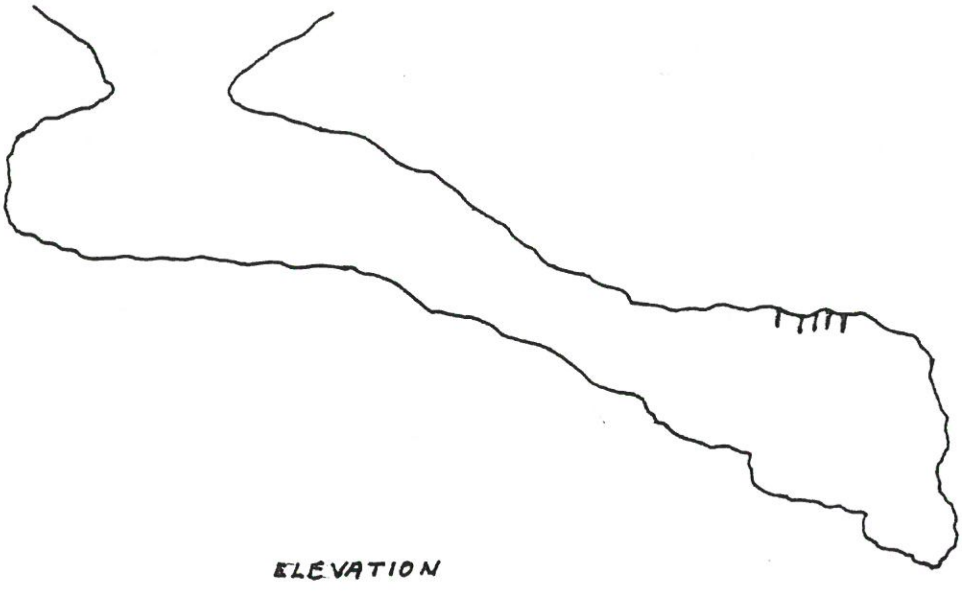


ELEVATION

B4

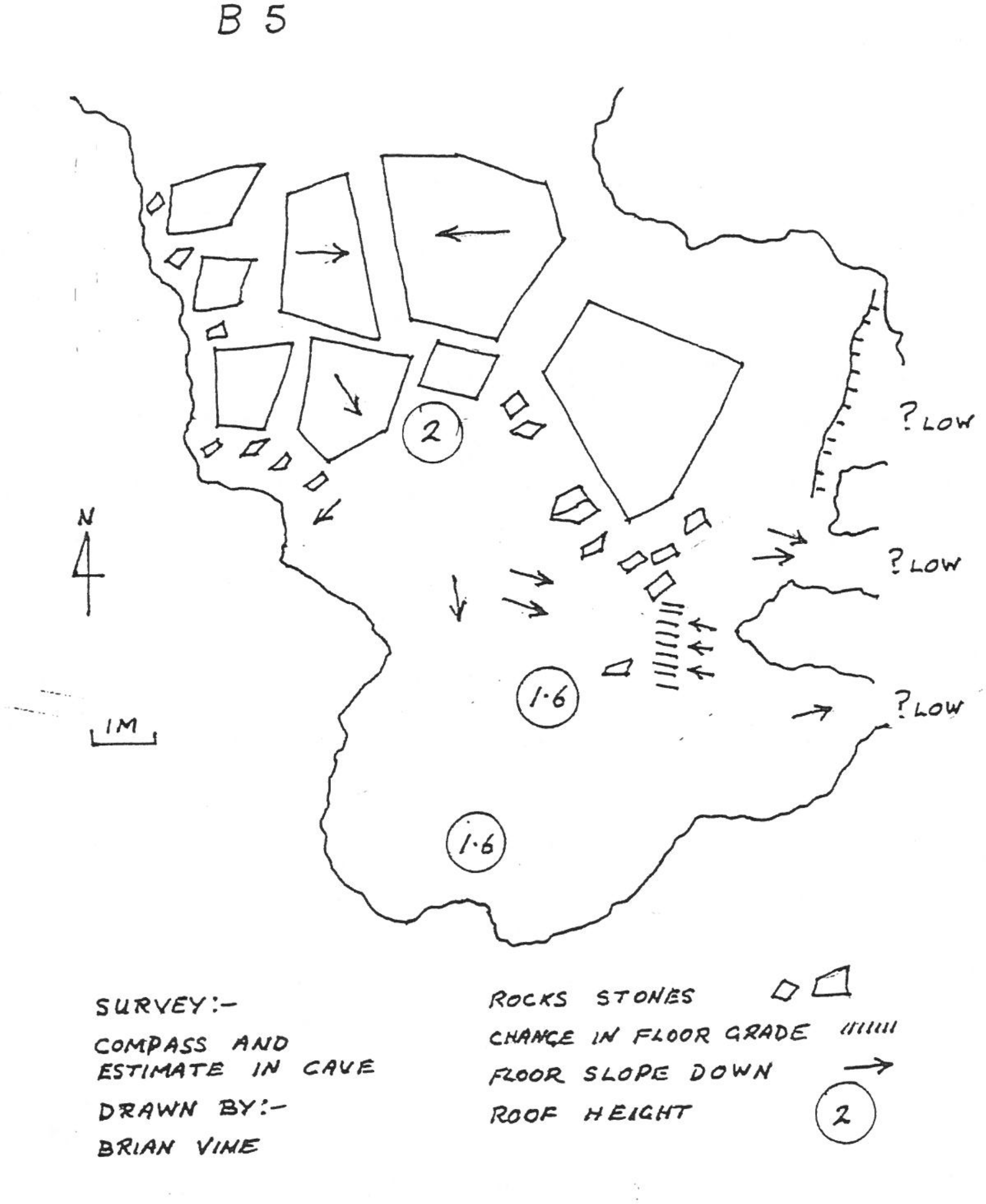


PLAN



ELEVATION

B5


B 5
2
?LOW
?LOW
?LOW
N
1·6
1M
1·6
SURVEY:-
COMPASS AND
ESTIMATE IN CAVE
DRAWN BY:-
BRIAN VINE
ROCKS STONES
CHANGE IN FLOOR GRADE
FLOOR SLOPE DOWN
ROOF HEIGHT
2

Appendix 3: Temperature and humidity of some caves on Barrow Island in September 1991. Temperature and relative humidity were spot measured by whirling hygrometer (Brannan, England). Soil water content was determined gravimetrically .

Cave	Date	Temperature °C	RH %	Vapour pressure hPa	Location
B1	5.9	27.6	96	35.3	Main chamber
B1	5.9	28.0	93	35.5	Main chamber
B1	5.9	28.2	97	37.1	Small water pool, flowing seawater
B1	5.9	27.9	97	36.4	Mudhole mud 26.3%
B1	6.9	27.6	98	35.3	Schizomid area
B1	6.9	27.8	96	35.9	1m below schizomid area
B1	11.9	27.3	96	36.1	Main chamber
B1	11.9	28.0	99	37.5	Schizomid area
B1	11.9	27.7	97	36.0	Mudhole
B1	12.9	27.3	99	36.0	Mudhole cracking mud 23.1%
B1	12.9	26.3	100	34.2	Main chamber
B2	8.9	25.1	63	20.1	Outside
B2	8.9	24.3	70	21.5	Inside
B3	4.9	29.3	73	29.6	Base: water added to cave
B3	7.9	28.8	88	35.0	Base
B3	12.9	27.2	85	31.0	Base
B3	12.9	29.0	79	31.7	Base
B4	7.9	24.7	56	17.6	Upper chamber
B4	7.9	24.8	63	19.8	Lower chamber
B4	7.9	25.1	81	24.6	Upper aven
B5	7.9	26.2	47	16.0	Mouth of cave in doline
B5	7.9	25.6	57	18.0	Surface
B5	7.9	23.8	69	20.4	Back of cave
B5	7.9	23.7	77	22.4	Left back chamber
B10	9.9	23.4	62	17.8	Surface
B10	9.9	28.8	79	31.2	Bottom 30m

Appendix 4: The identity of collections made on Barrow Island in September 1991 by W.F. Humphreys *et al.*

Determined material

Class	Order	Family	Genus & species
DIPLOPODA			
	Spirobolida		Gen. nov. sp. nov. (**troglobite**)
CHELICERATA			
	Pseudoscorpionida		
		Atemnidae	*Oratemnus* sp. nov. (**troglobite**)
	Schizomida		*Draculoides* sp. nov. (**troglobite**)
	Araneae		
		Araneidae	*Argiope protensa*
		Ctenidae	
		Desidae	*Badumna* sp.
		Gnaphosidae	
		Heteropodidae	
			Heteropoda sp.
		Oecobiidae	*Oecobius* sp.
		Pholcidae	
		Prodidomidae: Molycriinae	
		Salticidae	*Zenodorus orbiculatus*
			Holoplatys sp
		Theridiidae	
		Trochanteriidae	*Corimaethes* sp.
			Fosterina sp.
		Zodariidae	*Habronestes* sp.
INSECTA			
	Blattaria	Nocticolidae	*Nocticola* sp. nov. (**troglobite**)
	Hemiptera		
		Reduviidae: Stenopodainae	
			Centrogonus sp. B3, B5
		Emersinae	*Stenolemus giraffe* Wygodzinsky B5, B8.
CRUSTACEA			
	Isopoda	Armadillidae: Buddelundiinae	
			[1] New genus, new species Dalens
B2, B3			
			Buddelundia labiata B.-L., 1912. WAPET Camp
		Philosciidae	*Laevophiloscia yalgoonensis* Wahrberg 1922 B1, B3
		Ligidae	*Ligia australiensis* Dana, 1853. Camp beach
		Olibrinidae	[2] *Olibrinus* sp. Camp beach
		?Oniscidae	?*Hanoniscus* : (**troglobite**), B1 Found dead.

[1] The new genus and species in the Buddelundiinae is only the second genus in the sub-family. [2] *Olibrinus* sp. is the first member of the family Olibrinidae from the Indo-Pacific area. Collections made on Barrow Island in early September 1991. The collectors were W.F. Humphreys, B. Vine, W.H. Butler, D. Goodgame & J. Angus.

Appendix 4 continued

Material collected

Taxon	**Samples**	**Individuals**
Annelida	1	1
Chelicerata: Acarina	7	27
Chelicerata: Araneae	10	11
Chelicerata: Araneae: *Argiope* sp.	1	1
Chelicerata: Araneae: Heteropodidae	3	3
Chelicerata: Araneae: Pholcidae	8	11
Chelicerata: Araneae: Salticidae	4	8
Chelicerata: Pseudoscorpionidae	1	3
Chelicerata: Schizomida, *Draculoides* sp. nov.	4	5
Chilopoda: Geophilida	2	2
Chilopoda: Scutigerida	1	1
Diplopoda	3	4
Crustacea: Amphipoda	1	1
Crustacea: Isopoda : Armadillidae	3	40
Crustacea: Isopoda: Philosciidae	10	29
Insecta: Blattodea:	4	4
Insecta: Coleoptera	8	11
Insecta: Collembola	3	6
Insecta: Diptera	1	1
Insecta: Formicoidea	8	22
Insecta: Homoptera	9	9
Insecta: Isoptera	2	7
Insecta: Psocidae	2	2
Insecta: Thysanura	1	3
Mollusca: dead	7	11
Miscellaneous	11	11
Total	115	234

D.C. Lowry collected material from caves in July 1976 (Pholcid and Lycosid spiders?) from 'F-cave" (clearly B6) and "Malouet Cave" (clearly B2). They are WAM numbers 76/105-112 and have not been determined to species level. The Pholcidae are in The Netherlands be examined by Dr C. L. Deeleman-Reinhold.

76/107 - Cycloctenidae; juvenile determined by M.R. Gray . "Malouet Cave, Barrow Is. W. Australia. David Lowry leg. 19.7 1976; cat 49/29". This is the first known collection of the family Cycloctenidae in Western Australia. They were recently found in the south-west of WA collected in 1990 from the wet forest block their normal habitat (M.S. Harvey, pers. comm. 1990). This is cave B2.

76/112 - Amaurobiidae; determined by M.R. Gray . "F- Cave, Barrow Is. W. Australia. David Lowry leg. 28.7 1976; cat 49/27". This is cave B6 which has been used for the disposal of oily waste water