THE FOG-BASKERS OF THE NAMIB DESERT

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The flightless black tenebrionid beetle, Onymacris unguicularis, lives in the almost vegetationless dunes of the Namib Desert. It is one of a number of dune endemic species being studied by Dr. Mary K. Seely, Director of the CSIR's Desert Ecological Research Unit at Gobabeb, South West Africa, and visiting scientist Prof. W.J. Hamilton III of the University of California, Davis. They have recently quantified the amount of fog water taken up by these beetles in the Namib dunes.

The question of how desert fauna and flora obtain their water has long intrigued scientists. The presence of moisture from the irregular nocturnal fogs which arise from the cold Benguela current flowing along the warm west landmass of Southern Africa is considered to be the basic reason that life has evolved in this ancient dune ecosystem, which supports a unique endemic fauna and flora without counterpart elsewhere on earth.

O. unguicularis are diurnal beetles with large black bodies 20 mm long, and they forage on the dune slipface during the morning and afternoon, feeding on windblown seeds and other organic plant matter. Their period of greatest activity, when they are very conspicuous against the bare red sands, coincides in the late afternoon with the strongest winds which transport the plant detritus on which they feed. Towards evening they bury themselves by swimming through the soft loose sand of a dune slipface, where they remain until morning.

These beetles are not ordinarily active at night, but during noctural fogs they emerge and climb in a slow, deliberate manner to the crest of the dune, where they assume a characteristic head-down stance facing into the fog-laden wind. This is termed "fog-basking". Dune slipfaces oriented into the wind also intercept fog. Beetles emerging there at once adopt the typical head-standing posture. As the fog moisture condenses on the beetles, it trickles drop by drop along narrow grooves in the shell into the mouth, where it is consumed.

For four months daily field observations were made on beetles living on the sand dunes south of the Kuiseb River, an area which included 5 km of dune ridges. All specimens collected were merked with small numbered discs glued to the thorax. When 90 per cent of all beetles collected had been numbered and released, their head-standing positions on the dune crests on foggy mornings were marked and they were again collected for mass measurements.

In general, fog water intake accounted for an average increase of 12 per cent in mass. The maximum gain by an individual in a single fog was 34 per cent of its total pre-fog body mass. A control sample of beetles whose mass was measured, was marked, released and recaptured after a fogless night, when their mass was measured once more. Of 48 such recaptures the average mass loss was just over one per cent. Any mean mass increase by a population of beetles during an overnight fog can thus be ascribed to an intake of fog moisture.

Other groups of beetles, spiders and silver fish have been found active on foggy mornings. Direct collection of fog water seems to be important in the water economy of Namib Desert creatures, and to involve in certain cases highly developed methods.

Pta-1580. Homeb 7 6830 ± 70

$\delta^{13}C = -0.1‰$

Slightly calcified level just below Homeb 6 in silt. Coll 1975. *Comment:* $CaCO_3$ content 4.5 %, all carbonate used for analysis.

General Comment: carbonate of latter two samples may derive from overlying conglomerate (Homeb 8, above) by the agent of water percu-lating (through the sand and accumulating) on the top of the silts, thus explaining the young dates.

Pta-1091. Gobabeb root-cast 20870 ± 230

$\delta^{13}C = -5.2‰$

Calcified root-cast from dune valley (23° 32' S, 14° 58' E), 6.5km W of Gobabeb and 1km S of Kuiseb ri, possibly of Narra plant that grew when more moisture was available. Coll and subm 1973 by M K Seely. *Comment:* 22% of carbonate removed with acid and rest analysed. Compare similar dates for Homeb silts, above.

Pta-1492. Homeb 2 22320 ± 320

$\delta^{13}C = -2.4‰$

Calcified crust *c* 6.8m below top of silt. Coll 1975. *Comment:* $CaCO_3$ content: 1.7 %, all carbonate used for analysis.

Pta-2083. Homeb 14 18080 ± 160

$\delta^{13}C = -1.9‰$

Calcified crust *c* 8m below top of silt. Coll 1977. *Comment:* first 7 % of sa discarded. $CaCO_3$ content: 10.8 %.

Pta-1862. Homeb 15 25000 ± 350

$\delta^{13}C = -1.5‰$

Calcified crust *c* 11.5m below top of silt. Coll 1977. *Comment:* first 38 % of sa discarded and rest analysed. $CaCO_3$ content: 30.6 %.

Pta-1822. Homeb snails 23540 ± 660

$\delta^{13}C = -1.8‰$

Small freshwater gastropod shells from lower half of silt deposit. Coll 1974 by B Sandelowsky and 1975 by J C Vogel. *Comment:* first 15 % of 7.6g sa discarded and rest analysed.

General Comment: extremely low carbonate content of silt levels intervening calcified crusts indicates absences of primary carbonate in deposit. Since calcificiation must have taken place during desiccation of floodwater accumulations in the course of silt accumulation and recent contamination by rain or fog seems to be absent in region (see Meob and Conception reeds, above), results expected to date deposition of silt and thus damming of Kuiseb ri at about 20 000 BP.

Pta-2008. Homeb 16 10560 ± 110

$\delta^{13}C = -6.1‰$

At mouth of side valley and closer to present river bed *c* 3m silt occurs on top of coarse river gravel at *c* 9m above river. 50cm above gravel calcified crust coll 1977 for analysis. *Comment:* first 15 % of sa discarded and remainder analysed. $CaCO_3$ content: 12.7 %. Deposit apparently much more recent than silts described above.

Pta-1548. Homeb 6 12680 ± 100

$\delta^{13}C = -1.3‰$

Slightly calcified level on top of silt visible on S bank of Kuiseb ri *c* 30m above bed and separated from cemented gravel remnant (Homeb 8, above) by *c* 10m sand. Coll 1975. *Comment:* $CaCO_3$ content 7.7 %, all carbonate used for analysis.

Homeb series

At Homeb (23° 38' S, 15° 09' E) 15km upstream from Gobabeb in Kuiseb ri gorge, 100km SE of Walvis Bay, remnants of well stratified lacustrine-like silt sediments occur, possibly deposited in stormwater lake at time when Kuiseb ri was blocked by sand dunes (Scholz, 1972). In upper part of *c* 35m sedimentary column numerous thin carbonate-cemented layers are present. In lower part small freshwater gastropod shells are found. An attempt was made to date formation by means of these carbonates and shells. In addition samples of calcrete crust on desert plain between dunes S of river and carbonate cement of coarse gravel *c* 40m above river bed on S bank were analysed. Samples coll and subm by J C Vogel.

Pta-1494. Homeb 9 calcrete 28940 ± 490

$\delta^{13}C = +0.1‰$

Younger generation of distinctly two-phase hardpan from *c* 110m above river bed on top of S bank of Kuiseb ri at Homeb. This hardpan crust occurs extensively in dune streets between river and Tsondabvlei. Coll 1975. *Comment:* 19 % of sa removed with acid and rest analysed. $CaCO_3$ content: 32 %.

Pta-1493. Homeb 8 conglomerate 29440 ± 520

$\delta^{13}C = -3.3‰$

Calcium carbonate cement of remnant of coarse river gravel protruding from S bank of Kuiseb ri at Homeb *c* 40m above river bed. Coll 1975. *Comment:* first 21 % of sa rejected, remaining carbonate analysed. $CaCO_3$ content: 38 %.

General Comment: similarity of dates for Sa 8 & 9 suggests possible period of desiccation at *c* 29000 BP; see also similar date for Narabeb root-cast, above.

Pta-1861. Homeb 11 20120 ± 220

$\delta^{13}C = -2.4‰$

Thin calcified crust on top of silt deposit *c* 35m above river bed inside valley N of Kuiseb ri. Coll 1977. *Comment:* first 36 % of sa rejected and remaining carbonate analysed. $CaCO_3$ content: 33 %.

Pta-1860. Homeb 13 root-casts 19580 ± 170

$\delta^{13}C = -8.5‰$

Carbonate root-casts (?) from 1m below top of silt deposit. Coll 1977. *Comment:* first 44 % of sa rejected and rest analysed. $CaCO_3$ content: 56 %.

Tsondab Lower Valley series

Tsondab ri deriving from the escarpment ends in Tsondab vlei, but previously extended much further W into the Namib sand desert. Some 6km W of present Tsondab vlei remnants of silt deposits occur on N edge of former lower valley of Tsondab ri (23° 53' S, 15° 15' E) (Seely & Sandelowsky, 1974). In upper part of silt several thin calcified layers occur, representing repeated flooding and dessication.

Pta-1502. Tsondab Lower Valley silt 14320 ± 125

$\delta^{13}C = -2.8‰$

Calcified layer in upper section of silt deposits protruding from underneath dune sand. Coll and subm 1975 by J C Vogel. *Comment:* sample contained 5.3% carbonate which was all used for analysis. Oxygen-18 content, $\delta^{18}O = -6.96‰$ indicates mainly fresh water carbonate thus date probably reliable.

Pta-1043. Tsondab Lower Valley snails 13270 ± 90

$\delta^{13}C = -7.1‰$

Small shells of fresh water snails, *Lymnaea natalensis* and *Biomphalasia pfeifferi*, mostly from slightly lower level than silt sample (Pta-1502, above). *Comment:* 23% of carbonate removed with acid and rest analysed.

General Comment: similarity of results indicate reliability of date from silt and suggest extensive flooding before *c* 14000 BP. Subsequently lower valley was blocked by high sand dunes to E forming present Tsondabvlei.

Pta-1197. Narabeb root-cast 28480 ± 500

$\delta^{13}C = -3.2‰$

Calcified root-casts(?) from site called Narabeb (23° 55' S, 14° 55' E), 38km W of Tsondabvlei and 47km from coast in former lower Tsondab ri valley, central Namib desert. Pedotubles originate from above extensive hardpan, but are at lower level than silt deposits along E edge of dune valley (Seely & Sandelowsky, 1974). Coll and subm 1973 by M K Seely. *Comment:* 34% of carbonate removed with acid and rest analyzed. Compare similar dates, Pta-1493 and Pta-1494, Homeb series, below.

Sossusvlei Silt series

At Sossusvlei (24° 45' S, 15° 21' E), in central Namib desert, flood-waters from the Tsauchab ri have left extensive silt deposits. In SW corner lobe of vlei has been cut off by high sand dunes. Small portion is 3m lower than rest of lobe floor. Dating of dead trees in this lobe given below.

Pta-1859. Sossusvlei silt 4 24820 ± 320

$\delta^{13}C$ -1.8‰

Calcareous silt from 2.85cm below surface of lower floor in separate lobe of vlei. Coll 1976; subm 1977 by E M van Zindern Bakker, Institute of Environmental Sciences, Univ of OFS, Bloemfontein. *Comment:* calcium carbonate content 4.4% of which unknown fraction is primary carbonate. 14% of carbonate rejected and remaining proportion analyzed.

Pta-1579. Sossusvlei silt 2 9600 ± 85

$\delta^{13}C = -2.0‰$

Calcareous silt from 5 to 10cm below surface of upper floor of separated lobe of vlei. Coll and subm 1975 by J C Vogel. *Comment:* calcium carbonate content 4.2%. All carbonate used for analysis.

Pta-1503. Sossusvlei silt 1 9460 ± 85

$\delta^{13}C = -2.6‰$

Calcareous silt from 0 to 5cm below surface of upper floor of separated lobe of vlei. Coll and subm 1975 by J C Vogel. *Comment:* calcium carbonate content 5.4%. All carbonate used for analysis.

General Comment: if Sa 1 and 2 assumed deposited in sub-recent times then 2/3 of carbonate is primary without carbon-14. Then Sa 4 would be *c* 16000 yr old. Assumption supported by ^{13}C-contents. Pollen spectrum in silt similar to that of present vegetation (Van Zindern Bakker, pers commun).

Pta-1646. Sossusvlei silt 3 (106.4 ± 2.5)%

$\delta^{13}C = -21.0‰$

Organic material separated from large sample of silt from 2.4m depth in active lobe of Sossusvlei, near present endpoint of Tsauchab ri. Coll and subm 1975 by E M van Zindern Bakker. *Comment:* pit dug close to evaporating flood-water pool revealed successive layers of silt and sand. Large sample of silt from bottom of pit digested with hydrofluoric acid and remaining 0.3g organic material analyzed. Com-

parison with curve for atmospheric ^{14}C-content (Vogel & Marais, 1971, p 392) suggests date of AD 1957, ie 17 years old in 1975.

Pta-1287. Langewandt oyster 7640 ± 80

$\delta^{13}C = +1.3‰$

Ostrea shell lying on stormwater beach at N end of the Langewandt, (23° 39' S, 14° 31' E), 28km S of Sandwich Bay together with driftwood, planks etc that have been washed up in recent times. Coll and subm 1973 by J C Vogel. *Comment:* half of sample removed with acid and remaining carbonate dated. True age *c* 400 yr younger. Sample collected because occurrence of oysters on this rockless stretch of coast was strange. Probably shells are washed up from fossil submerged oyster bed. Demonstrates danger of using shell to date fossil beaches, compare Reutersbrunn oyster, Pta-1235 : 6750 ± 75, above. See also Grn-4858 : 7650 ± 70 for *Ostrea* shell from sea bottom, and GrN-4857 : 1610 ± 50 for *Donax* shell from above beach in same area (R, 1970, v 12, p 450).

Pta-1501. Tsondabvlei silt 8640 ± 70

$\delta^{13}C = -2.9‰$

Slightly calcareous silt from surface near entrance to Tsondabvlei (23° 56' S, 15° 22' E), central Namib desert. Coll and subm 1975 by J C Vogel. *Comment:* sample contained 4.5% calcium carbonate which was used for analysis. Silt deposits here frequently submerged and possibly reworked by flood waters entering vlei thus representing a different situation to fossil deposits in Tsondab lower valley and Homeb silts (below) which were apparently deposited in still water and subsequently calcified. Oxygen isotopic composition, $\delta^{18}O$ = -9.48‰, indicates pure fresh water carbonate.

Conception saltpan series

Extending S from Conception Bay (23° 56' S, 14° 30' E) is large saltpan separated from beach by sand barrier, now completely dry but with signs of recent submergence. Samples coll and subm 1977 by J C Vogel to date disappearance of coastal lagoon.

Pta-1833. Conception tree 440 ± 50

$\delta^{13}C = -25.6‰$

Outer annual rings of large tree trunk lying in middle of saltpan *c* 7km W of waterhole. Apparently washed up by sea at time when lagoon still existed. *Comment:* pretreated with acid and alkali.

Pta-1826. Conception small shell 920 ± 50

$\delta^{13}C = +0.8‰$

Donax serra bivalves standing upright in pairs in living position on 50cm shell beds on top of saltpan surface *c* 6km W of waterhole. *Comment:* 39% of sample removed with acid and remaining carbonate analyzed.

Pta-1827. Conception large shells 940 ± 50

$\delta^{13}C = +0.9‰$

Lutraria capensis bivalves standing upright in pairs on 50cm shell beds on top of saltpan surface in living position near *Donax* colony (Pta-1826, above). *Comment:* 33% of sample removed with acid and remaining carbonate analyzed.

General Comment: due to apparent age of surface seawater, *c* 400 yr must be subtracted from seashell dates to obtain true date. Thus shells (520 BP and 540 BP) only insignificantly older than tree (440 BP) suggesting that lagoon still existed in first half of 15th century (calibrated date). *Donax* prefers wave action while *Lutraria* may occur in lagoons (R N Kilburn, pers commun).

Conception reed series

In surroundings of watering place at Conception Bay (24° 01' S, 14° 34' E), 10km S of landing place, fresh water occurs 3m below surface. Remnants of flat surface capped with calcrete layer containing calcified reed stalks, protrude from extensive deflation area. Samples coll and subm 1973 by J C Vogel.

Pta-1238. Conception reeds 1 11850 ± 100

$\delta^{13}C = -6.6‰$

Calcified reed stalks, probably *phragmites*, from calcrete surface 4.1m above deflation plain at watering place, Conception Bay. *Comment:* 12% of sample removed with acid and remaining carbonate dated.

Pta-1647. Conception reeds 2, fr. 1 12530 ± 120

$\delta^{13}C = -8.6‰$

Pta-1648. Conception reeds 2, fr. 2 12580 ± 140

$\delta^{13}C = -9.0‰$

Two fractions of another sample of calcified reed stalks from same locality as Pta-1238, above. *Comment:* to test for recent contamination of calcium carbonate sample was treated as follows: first 10% carbon dioxide evolved on acidification rejected, next 40% collected - fraction 1; next 10% rejected, remaining 40% collected - fraction 2.

General Comment: fact that fr. 1 and 2 of sample 2 give identical results suggests contamination insignificant. Three dates together indicate lowering of groundwater table and calcification of extensive reed marsh about 12000 BP (see Meob series, above).

Meob series

22km SE of Meob Bay (24° 31' S, 14° 37' E), 175km S of Walvis Bay, fresh water occurs 2m below surface of extensive deflation area. Remnants of flat surface capped with calcrete layer protrude *c* 4m above plain near dune field margin. Calcified reed stalks coll from calcrete surface behind first dune ridge on inland side of plain, and subm 1977 by J C Vogel, indicate former higher groundwater table.

Pta-1830. Meob reed fr. 1 — 11800 ± 85
$\delta^{13}C = -9.2‰$

Pta-1831. Meob reed fr. 2 — 11670 ± 120
$\delta^{13}C = -9.3‰$

Calcified reed stalks, probably *phragmites*, from calcrete surface inland from coast. *Comment:* to test for recent contamination of calcium carbonate sample treated as follows: first 10% carbon dioxide evolved on acidification rejected; next 48% collected as fraction 1; next 10% rejected; final 32% collected as fraction 2. Similarity of results for two fractions exclude significant post-depositional contamination. Date suggests significant lowering of groundwater table and formation of calcrete layer at about 12000 BP, ie at same time as similar event at Conception Bay, below.

Pta-1285. Reutersbrunn Oyster — 6750 ± 75
$\delta^{13}C = +1.4‰$

Ostrea atherestonei shell from surface of stormwater beach at Reutersbrunn (24° 43' S, 14° 46' E), 30km S of Meob Bay. Coll and subm 1983 by M K Seely, Namib Desert Research Station, Box 953, Walvis Bay. *Comment:* 30% of sample removed with acid and remaining carbonate dated. True age *c* 400 yr younger. Compare Pta-1287, Langewandt Oyster, below.

Conception Bay series

Fresh water available at 3m depth *c* 8km SE of old landing place at Conception Bay (24° 01' S, 14° 34' E) 110km S of Walvis Bay. Surroundings dotted with stone artefacts, shallow shell middens and often a human skeleton exposed by shifting sand.

Pta-1863. Conception bone 705 ± 50

$\delta^{13}C = -12.9‰$

Collagen from femur of intact adult skeleton buried in sand in crouched position and still covered with hair probably of caross in which corpse was wrapped (Kolb, 1719), some 200m N of German water hole. Coll and subm 1977 by J C Vogel. *Comment:* purified collagen prepared from 50g bone.

Pta-902. Conception pot CP1 620 ± 40

$\delta^{13}C = -17.5‰$

Carbonaceous matter scraped from surface of broken bag-shaped pot with pointed base, decorated neck and 2 externally applied, horizontally pierced lugs, found in sand near skeleton CB2. Coll and subm 1973 by J C Vogel.

Pta-1801. Conception pot CP2 310 ± 20

$\delta^{13}C = -19.0‰$

Carbonaceous matter scraped from surface of bag-shaped pot with pointed base and 2 horizontally pierced lugs found 1976 by B Kensley near old house at "windmill" and subm 1976 by L Jacobson. *Comment:* most probable calibrated date between AD 1490 and 1620.

Pta-1834. Conception midden 220 ± 50

$\delta^{13}C = -21.5‰$

Scattered charcoal from shallow shell midden close to CB 1 and 2 on which copper bead was noticed. Coll and subm 1977 by J C Vogel. *Comment:* most probable calibrated date AD 1650.

General Comment: Conception Water Place obviously visited over many centuries in this millennium in connection with utilization of marine resources.