

Aspects of phenology and condition of inland and coastal !Nara plants in the Namib-Naukluft Park, Namibia

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Abstract

Two inland and one coastal population of !Nara plants were monitored from December 1989 to August 1992. Distances between plants (4 - 500 m) and the ground surface areas covered by them (0.2 m² - 2 335 m²) varied greatly. There was no significant difference in sex ratio. Male plants flowered throughout the year whereas females flowered seasonally. Fruit production rates were highest at the coastal study site where one plant produced 321 fruit. Condition ratings of both male and female plants were highest at the inland river site, indicating the availability of ground water. The sparse rainfall in the desert apparently did not influence the condition of the plants or fruit production rates. The mass of !Nara fruit ranged from 678 g to 1 050 g with an average of 265 seeds per fruit. Energy values of fruit were high, measuring 231 kJ in fresh fruit and 2 709 kJ in the seeds. Mortality of !Nara at the coast rose sharply following salinity increases when severe attrition of their beach environment occurred.

Keywords: *Acanthosicyos horridus*, ethnobotany, fruit production, Gobabeb, Kuiseb, Namib desert, Sandwich Harbour, Topnaar Nama

Introduction and history

The !Nara, *Acanthosicyos horridus* Welw. ex Hook f., a perennial cucurbit endemic to the Namib Desert, grows on aeolian sands as well as rocky substrates. Its distribution appears limited to areas with a high water table. The plants are dioecious, their leaves are modified into thorns and photosynthesis takes place in both thorns and stems. !Nara plants occur mostly in the narrow fog belt along the coast, but there are scattered plants further inland in the Namib. Their range extends from Mossamedes in southern Angola to Port Nolloth, south of the Orange River, in South Africa (Figure1).

Fossil evidence suggests that !Nara already existed 40 million years ago (Louw *et al.* 1988) and seed coat fragments identified from an archaeological site at Mirabib Hill shelter near Gobabeb were dated at approximately 8 000 years old (Sandelowsky 1977). The explorers Alexander (1838) and Andersson (1857), as cited in Moritz

(1992) described !Nara plants that they encountered along the coast and the vital role that these plants played as a food source for the local inhabitants. A detailed botanical description of the !Nara was given by Sadebeck (1899) and by Dinter (1912). An analysis by Grimmer (1910) as quoted by Pfeifer (1979), showed that !Nara seeds contained up to 46 % oil and 32 % protein. Although !Nara melons are still used today by the indigenous Topnaars and form part of their cultural heritage (Dentlinger 1977), their importance as a major food source has declined in recent years because the melons have been mostly substituted by western food commodities (Shilomboleni 1998). Dinter (1912) reported that in 1897 about 200 Zentner of pips (the equivalent of 20 tonnes) were shipped annually from Walvis Bay to Cape Town where the kernels, also known as butter-pips, were used in the confectionery trade.

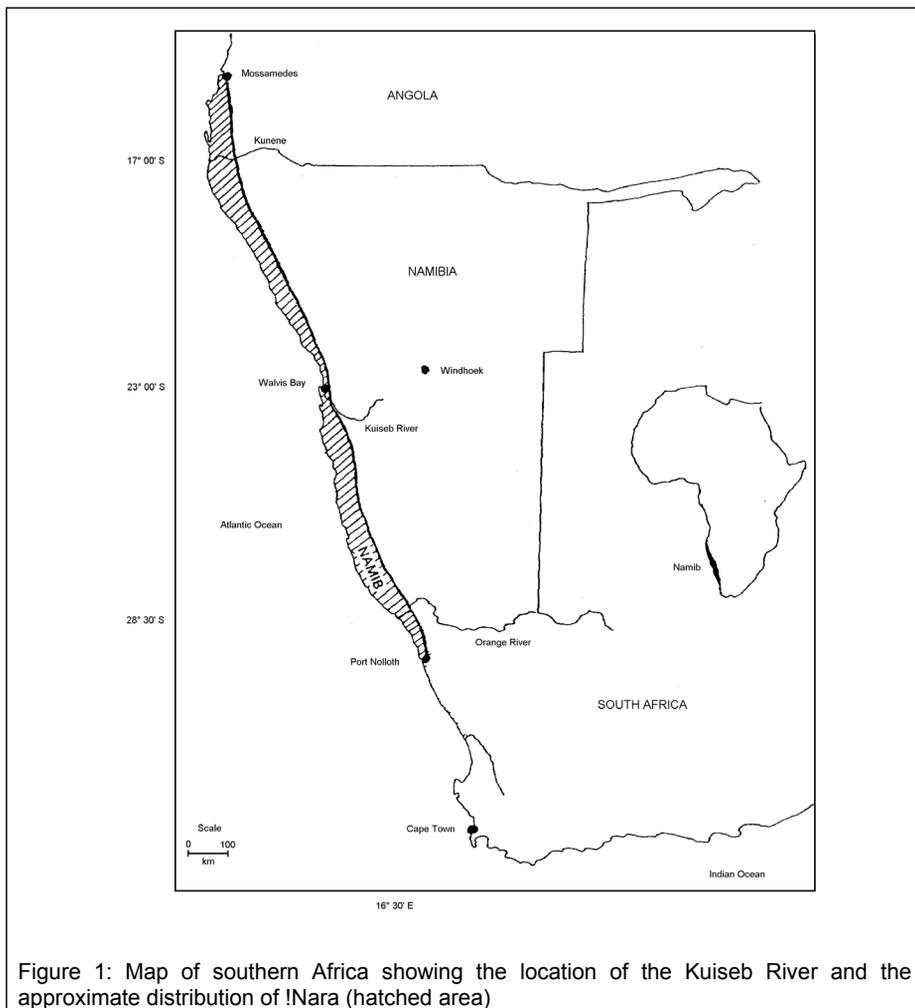


Figure 1: Map of southern Africa showing the location of the Kuiseb River and the approximate distribution of !Nara (hatched area)

Study area

Three separate !Nara populations were monitored in the Namib-Naukluft Park from December 1989 to August 1992. Two were situated in the vicinity of the Gobabeb Training and Research Centre on the Kuiseb River (23° 34'S, 15° 03'E, altitude 407 m). The third site was at Sandwich Harbour (23° 20'S, 14° 30'E, estimated altitude 5 m), a saltwater lagoon and fresh-water pools system, on the Atlantic Ocean coast about 40 km south of Walvis Bay (Figure 2).

The Central Namib Desert can be divided into four different climatic zones: the Coastal, Inland Foggy, Middle and Eastern Zones. There are three main seasons: January-April (typically hot with highly variable rainfall), May-August (alternating between cold fogs and hot, dry easterly winds) and September-December (high incidence of fog days with predominant south-westerly and north-westerly winds) (Henschel 1999).

Two of the study sites fall within the Middle zone, which lies between 40 and 90 km inland from the coast, with an average annual rainfall of 20.8 mm at Gobabeb (1962-1993, Meteorological Services, Windhoek). The third study site, Sandwich Harbour falls into the Coastal zone, with a mean annual rainfall of 15.2 mm (Henschel 1999).

Mean annual fog precipitation measured at Gobabeb is 30.8 mm with a mean of 37 fog days per year (Lancaster *et al.* 1984). No rainfall or fog precipitation records exist for the Sandwich site but it is similar to Walvis Bay, where fog precipitation is 34 mm and 65 fog days occur (Henschel 1999). The Kuiseb River flow ranges from zero to 102 days per year ($n = 38$ years). During 1990 it flowed 19 days but only six days during 1991 (Gobabeb weather station records).

One of the two inland study sites was in an inter-dune valley (hereafter referred to as the Dunes site), approximately 5 km south of Gobabeb. This site was accessible by quad bike and was monitored 21 times. All plants grew along the base of dunes at the edge of an inter-dune valley (1.5 - 2 km wide) on sandy and gravelly soils. Eleven plants (five males, five females, one of unknown sex) were sampled and marked with numbered plastic strips.

A second inland study area (hereafter referred to as the River site) was on the southern bank of the Kuiseb River, south-east of Gobabeb. It is easily accessible on foot and was monitored 21 times. Ten plants, five males and five females, of different sizes were marked and numbered. Nine plants grew on level surfaces of either gravelly or sandy soils; one plant, a female, grew on a dune slip face. The ten marked plants in the River site were all situated in close proximity to the river. A dune separated plants no. 1-4 from no. 5-10.

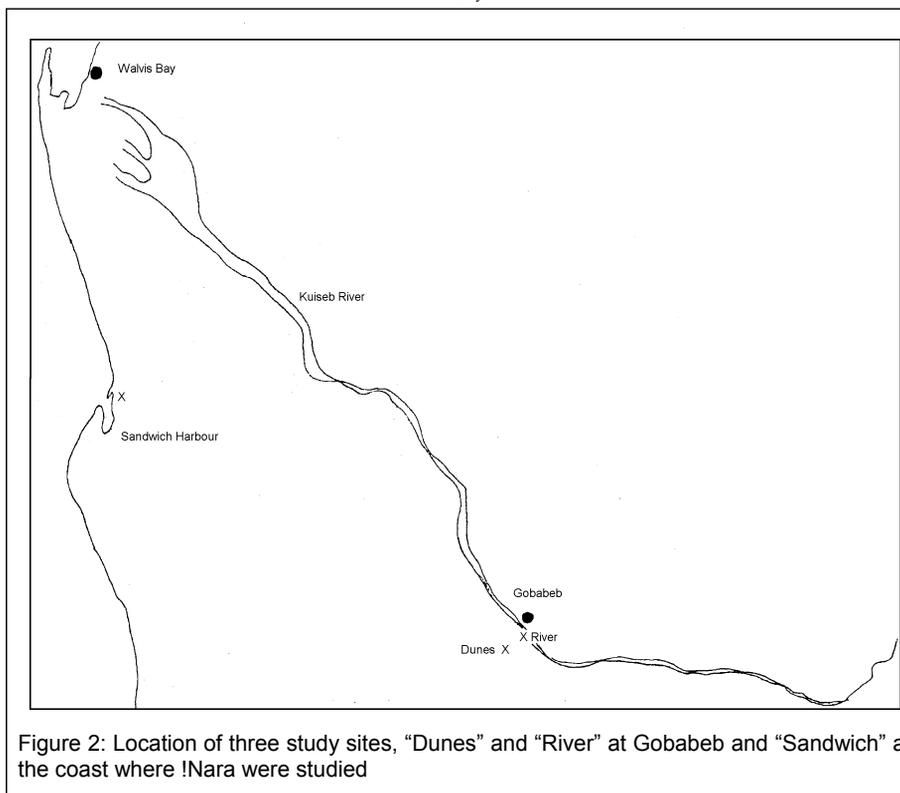


Figure 2: Location of three study sites, “Dunes” and “River” at Gobabeb and “Sandwich” at the coast where !Nara were studied

The perennial dune grass *Stipagrostis sabulicola* and a perennial succulent *Trianthema hereroensis* were the only plants recorded in the vicinity of both inland study sites.

The vegetation at Sandwich Harbour, the coastal study site, consisted of reeds (*Phragmites australis*), bullrushes (*Typha capensis*), *Scirpus* spp., *Capparis hereroensis*, *Lycium* spp., and *Heliotropium* spp.

The third study site was at Sandwich Harbour (hereafter referred to as the Sandwich site), approximately 55 km west of Gobabeb, on the coast (Figure 2). The Sandwich site was accessed by 4x4 vehicle and was monitored only 12 times due to the cost involved. For the first part of the study only five plants occurring in the northern wetlands were monitored. Two males and three females were marked and numbered. As from August 1991, when access to the Sandwich site improved, five additional plants were marked and monitored, two (one male, one female) in the northern section and three in the southern section (one male, two females).

Vertebrates occurring at the inland sites were gemsbok (*Oryx gazella*), springbok (*Antidorcas marsupialis*), black-backed jackal (*Canis mesomelas*), ostrich (*Struthio camelus*), domestic donkeys (*Equus asinus*), rodents (*Gerbillurus* spp.) and lizards (*Aporosaura* and *Meroles* spp.). Invertebrates recorded were dune crickets (*Acanthoproctus* spp.), meloid beetles (*Mylabris zigzaga*), tenebrionid beetles including (*Onymacris plana*, *O. laeviceps* and *Zophosis orbicularis*), wingless wasps or “velvet ants” (Fam. Mutillidae), spiders (Fam. Thomisidae and Salticidae), termites (*Hodotermes mossambicus*), dune ants (*Camponotus detritus*) and scale insects (Fam. Coccidae).

Vertebrates encountered at the coastal site were gemsbok, black-backed jackal, rodents and lizards. Invertebrates recorded were dune crickets, meloid and tenebrionid beetles, mealiebugs (Fam. Pseudococcidae), black aphids (Fam. Aphididae), weevils (Fam. Curculionidae) and dune ants.

Methods

Data were collected at irregular intervals, ranging from one to five months, during the period December 1989 to August 1992. General condition, new growth, percentage dead stems, flowers and their utilisation, fruit production and their utilisation of the !Nara were recorded. Fruit size was classified as small, medium and large. In addition, any association with other plants and the presence or absence of animals, including invertebrates, was noted. Tracks of animals occurring close to the sampled plants were identified where possible.

A subjective rating scale of 0 to 5 was used to evaluate condition, growth, flower and fruit production, flower and fruit utilisation, where:

- 0 = none observed
- 1 = very poor
- 2 = poor
- 3 = fair
- 4 = good
- 5 = excellent

Growth was measured by marking growing shoots with masking tape and measuring the new growth to the nearest centimetre.

Although growing shoots of the three different !Nara populations were marked and measured throughout the monitoring, the shoots were mostly chewed off by domestic and wild animals. Consequently, these results were discarded as unreliable.

Sex ratios and spacing between !Nara plants were recorded at the three study sites, as well as for separate communities of !Nara near the study sites. The estimated ground

surface areas covered by plants were calculated by using the formula $\pi r_1 r_2$ where r_1 is half the length of the ground surface covered by the plant and r_2 is half the breadth of the ground surface covered by the plant.

Ten fully ripe fruit from the inland study sites were collected at random and weighed. The number of pips in each fruit was counted. The wet flesh of the fruit was separated from the pips, both were air-dried for 41 days and weighed separately to calculate the moisture content of whole fruit, flesh and pips respectively. The percentage moisture in fruit (m) was calculated as total wet mass (x_w) minus total dry mass (x_d) divided by total wet mass (x_w) as follows: $m = (x_w - x_d) / x_w$.

The pH of the pulp was measured with pH paper strips (“Universalindikator” from E. Merck). Laboratory analyses were done on a combined sample of air-dried pips to determine absolute dry matter, organic matter and its major components, plus calcium (Ca) and sodium (Na) content. Energy was determined by standard bomb calorimetry at Wits University, Physiology Dept., 1991 (C. Brain, pers.comm.)¹. An unpublished, internal report, C.S.I.R. 1986, (G. Armbruster, pers. comm.)² provided an earlier, more detailed analysis of whole fresh !Nara plants and pips.

Results and discussion

Sex ratio and spacing

Table 1 shows the sex ratio, spacing and ground surface areas covered by !Nara plants in five study sites. Chi square analysis shows no significant difference from a 1:1 ratio ($\chi = 0.4321$, 1 d.f., $P > 0.05$).

Regression analysis shows no correlation in the distance between nearest-neighbour pairs and the sum of the surface areas of nearest neighbours ($R = 0.23$, $P > 0.05$). Distances between plants varied greatly, from as close as 4 m to 500 m. Consequently, individual !Nara plants appear to be able to survive in relative isolation from the nearest population. However, no additional new plants were established in the three study sites during the observation period. There are no significant differences in average plant size between the sexes. There are significant differences in average plant size between the study sites, however.

Mean surface area of plants at Sandwich ($n=10$, $x=944$) was significantly larger than that of plants at the Dunes site ($n=26$, $x=211$) ($t=3.371$, $P=0.006$) and that of plants at the River site ($n=14$, $x=70$) ($t=4.147$, $P=0.003$). Differences in surface area of plants

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²Ms. G. Armbruster, 22 Maiana, Maiana Ave, 0184 Brummeria, Pretoria, South Africa.

Table 1: Sex ratio, spacing and ground surface areas covered by *Inara* plants in five study sites

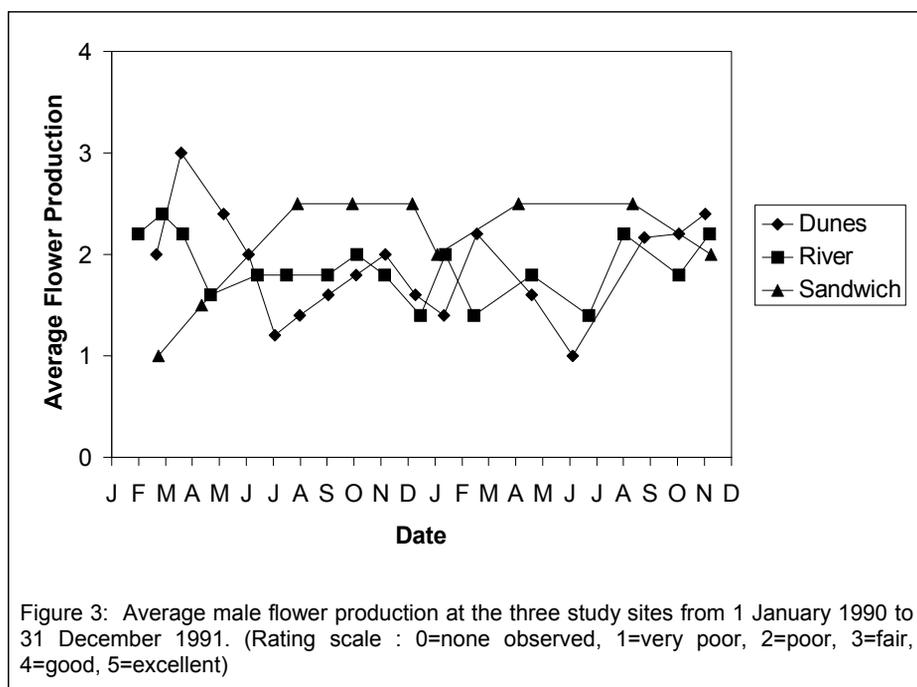
Site	Sex ratio	Distance to nearest plant (m)		Range of distances between plants (m)	Estimated ground surface areas covered by plants (m ²)						Range of estimated ground surface areas covered by plants (m ²)			
		Overall	Mean		SD	SE	Overall	Male	Female	Unsexed				
Dunes 1	5M:5F:1U	Overall	71		4 - 300	Mean	39	Mean	46	Mean	40	Mean	-	0.8 - 204
		SD	89			SD	68	SD	88	SD	56	SD	-	
		SE	28			SE	20	SE	40	SE	25	SE	-	
Dunes 2	5M:4F	Overall	44		5 - 70	Mean	486	Mean	683	Mean	240	Mean	-	35 - 1 237
		SD	23			SD	401	SD	426	SD	202	SD	-	
		SE	8			SE	134	SE	190	SE	102	SE	-	
Dunes 3	4M:3F:7U	Overall	173		10 - 450	Mean	56	Mean	123	Mean	65	Mean	14	0.2 - 311
		SD	157			SD	80	SD	126	SD	25	SD	26	
		SE	44			SE	21	SE	63	SE	14	SE	10	
River	9M:5F:4U	Overall	104		13 - 500	Mean	69	Mean	82	Mean	30	Mean	65	0.8 - 393
		SD	122			SD	107	SD	111	SD	50	SD	94	
		SE	30			SE	25	SE	37	SE	22	SE	47	
Sandwich	6M:4F	Overall	72		6 - 220	Mean	945	Mean	903	Mean	1010	Mean	-	253 - 2 335
		SD	71			SD	660	SD	507	SD	941	SD	-	
		SE	24			SE	208	SE	207	SE	470	SE	-	

between River and Dunes was just within the threshold of significance ($t=2.066$, $P=0.046$), the Dunes specimens being larger than the River specimens.

The ground surface area covered by individual plants also shows great differences, ranging from 0.2 m² (Dunes) to 2 335 m² (Sandwich). !Nara covering a ground surface area of less than 1 m² are presumably young plants, whilst those covering large ground areas must have been in existence for a long time. These !Nara often had exceptionally thick, woody root bases protruding above the sand, indicating an advanced age.

Male flower production

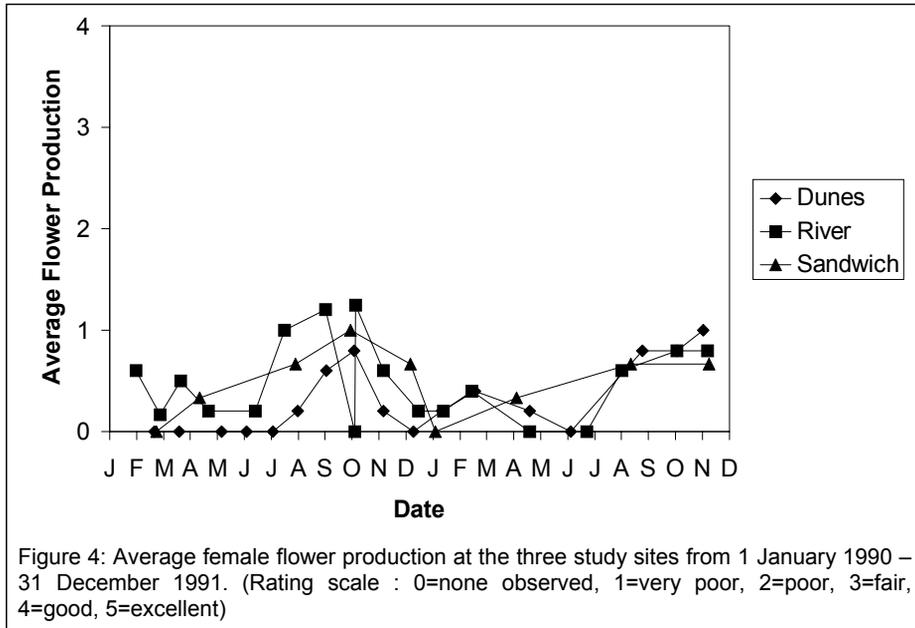
Male plants flowered to varying degrees throughout the year. At the Dunes site the average flower production peaked in March 1990 and again in March 1991 with a second peak in November 1991. At the River site the average flower production also peaked in March 1990 with a second peak in October. In 1991 the average flower production peaked in January with peaks in August and again in November. At the Sandwich site the average flower production in 1990 peaked from August to December. In 1991 it peaked from April to September. However, the maximum male flower production rates were higher in both the Dunes and the River site than at the Sandwich site.



Single Factor ANOVA showed no significant difference in the average flower production rates in males between the three study sites ($F = 0.9936$, 2 d. f., $P = 0.3792$).

Female flower production

In contrast to males, females flowered seasonally and generally produced fewer flowers. During 1990 the average flower production in the Dunes site peaked in October. During 1991 it peaked slightly in Feb/March and in November. At the River site the average flowering rate during 1990 peaked from September to October and in 1991 in October and November. At Sandwich the average flowering production in 1990 peaked in October and in 1991 from August to November/December.



Single Factor ANOVA showed no significant difference ($F = 1.016$, 2 d. f., $P = 0.3712$) in the average flower production rates in females between the three study sites.

Comparative flower production between males and females

A Mann-Whitney Rank Sum Test was done to compare average male and female flower production for all three study sites which showed that there is a statistically significant difference ($P < 0.001$) between male and female plants for all three study sites. The fact that males flowered throughout the year, whilst females flowered seasonally, may be due to an evolved survival strategy and/or an energy budget

strategy. Also, insect pollinators may have peaked seasonally during the periods of female flower production (Figures 5, 6 and 7).

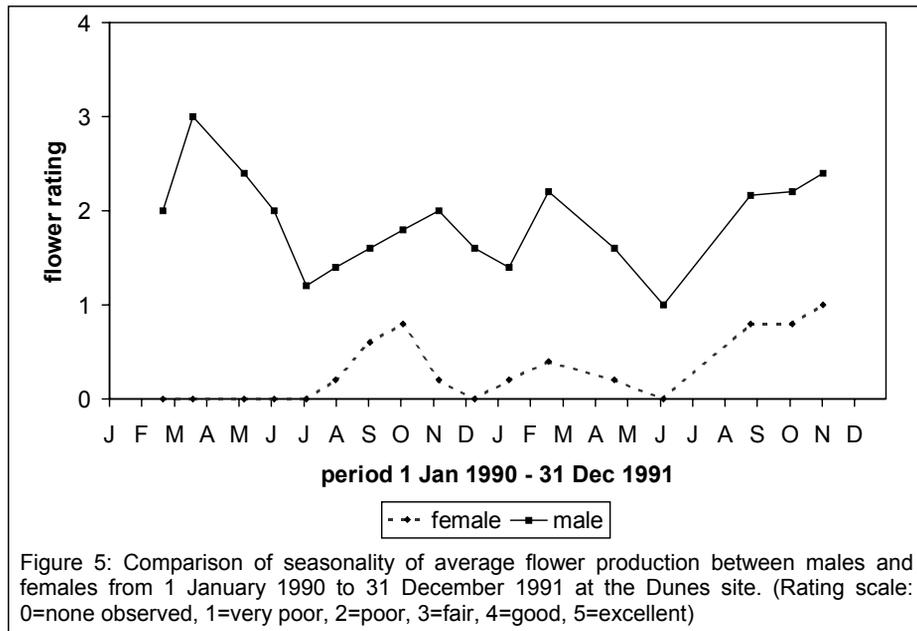
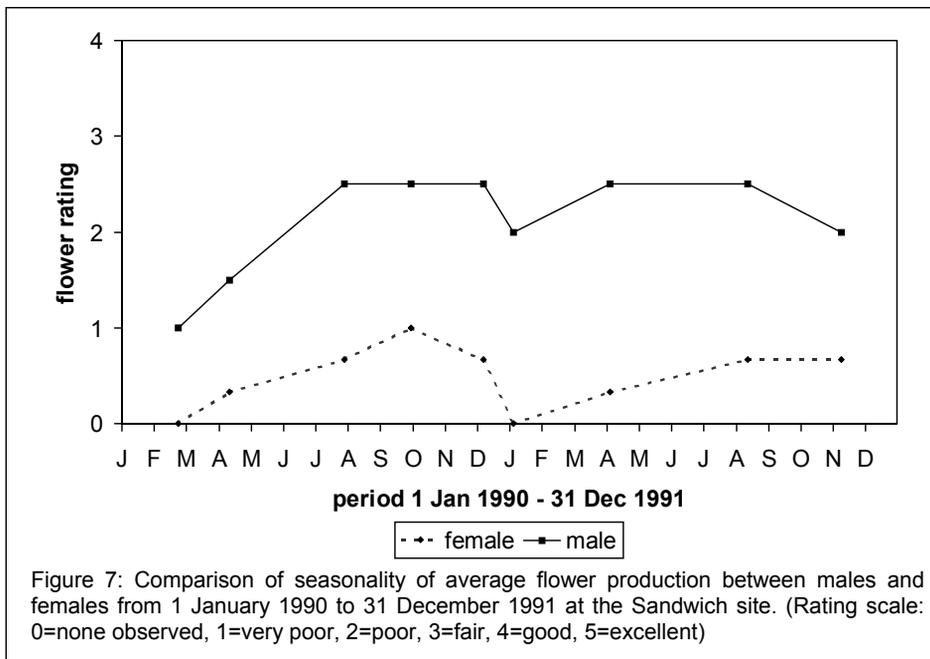
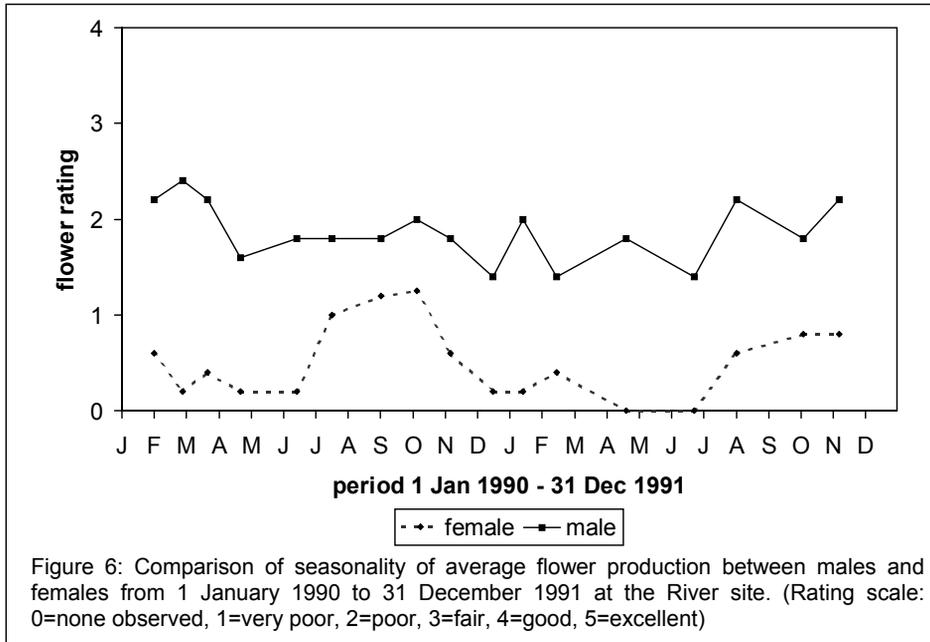


Figure 5: Comparison of seasonality of average flower production between males and females from 1 January 1990 to 31 December 1991 at the Dunes site. (Rating scale: 0=none observed, 1=very poor, 2=poor, 3=fair, 4=good, 5=excellent)

The average male flower production in the Dunes site during 1990 reached a peak in March and a second peak in November. During 1991 a peak was reached in March with another peak in November of the same year (Figure 5). Average female flower production peaked in October during 1990 and in November in 1991.

In the River site the average male flower production showed a peak in March 1990 and several peaks during 1991: in February, May, August, November. The average female flowering rate peaked in October/November during 1990 and in the same months during 1991 (Figure 6).

The Sandwich site does not reveal any noticeable peaks, however this may be due to infrequent monitoring. The highest average level was observed from August to December in 1990 and from April to September during 1991. The average female flowering rate peaked in October 1990 and from September to December in 1991 (Figure 7).



Fruit production

The highest fruit production occurred at the Sandwich site. A rating of excellent was recorded at the northern end of the fresh-water pools where one plant with an estimated ground surface area of 491 m², bore 321 fruit during December 1989. The same plant produced another 311 fruit in October 1990, 230 in January 1991 and 224 in August 1991. Another plant produced 226 fruit in January 1991 (Figure 8).

Fruit utilisation at the Sandwich site was also high: a heap of about 100 empty fruit husks was found nearby with jackal tracks and scats containing !Nara seeds. Some oryx spoor and numerous tracks of rodents were also present. In August 1991 five additional plants (three females and two males) were monitored for one year in the southern part of the study area. Their fruit production rate and utilisation was very low compared to the plants in the northern site. The highest number of fruit counted on one plant in the southern section was 26 compared to 321 in the north.

At the River site the highest fruit production rating was good. In December 1989 a total of 77 fruit was counted on one plant. In December 1990 a total of 46 fruit was counted on the same plant.

Fruit production was lowest at the Dunes site, where the highest fruit total recorded was 35 during January 1992. More fruit was utilised at the River site than at the Dunes site however. Numerous donkey tracks and fresh dung occurred around the female plants at the River site. These domestic animals, owned by Topnaars living along the Kuiseb River, had easier access to the River site than the Dunes site, which is situated relatively far from the river. The highest fruit production at the coast cannot as yet, be satisfactorily explained. There is also a further paradox, in that the coastal site had the highest fruit production, despite the plants having the poorest condition ratings.

Fruit characteristics

Table 2: Mass and number of pips of 10 !Nara fruit and the percentage moisture in whole fruit, flesh and pips of 5 fully ripe !Nara collected in March 1990.

	Total mass (g)	Range of mass (g)	Pips		% Moisture in fruit	% Moisture in flesh	% Moisture in pips
			Number	Range			
MEAN	820	678 – 1 050	265	222-305	82*	88*	44*
SD	98		25		5	4	15
SE	31		8		2	1	5

* n=5

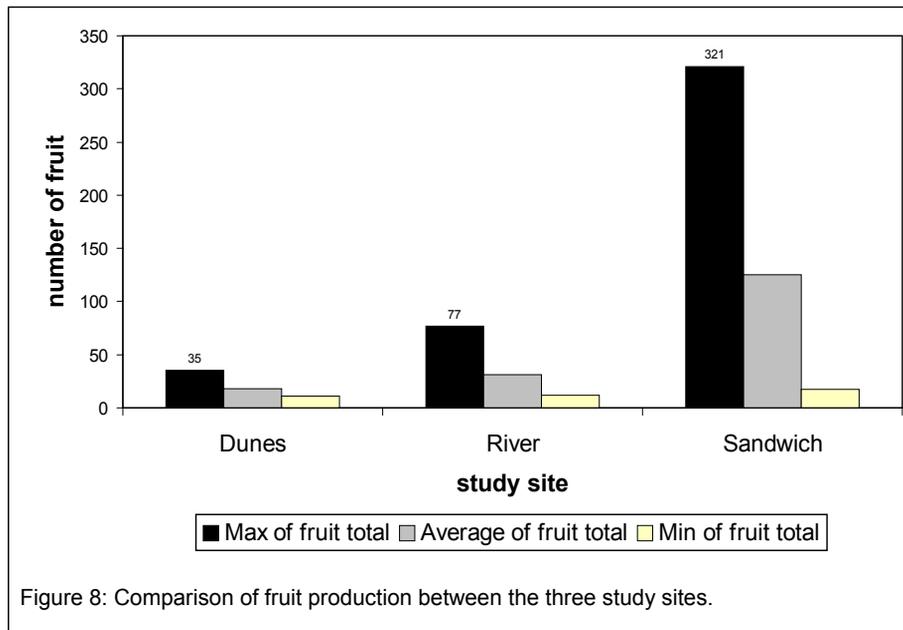


Figure 8: Comparison of fruit production between the three study sites.

Table 3: Laboratory analysis of air-dried !Nara pips from the present study (University of the Witwatersrand, Physiology Dept., 1991).

Sample	DM %	OM %	N %	Fibre %	NDF %	Ca %	Na ppm	Energy mg/kg
1	91.98	97.02	4.00	38.16	39.31	0.02	375.08	26.73
2	91.98	97.02	4.00	38.16	39.31	0.02	375.08	26.73

DM = dry mass
 OM = organic matter
 NDF = neutral detergent fibre

The pH of fresh fruit tested during this study ranged from 5,5 – 6; this may be due to a high content of oxalic acid (Herre 1975). Rehm *et al.* (1957), found that green !Nara fruits taste bitter due to the presence of cucurbitacins but lose their bitterness rapidly during ripening.

Table 4: Analysis (CSIR, unpublished report, 1986) from a separate sample of whole fresh !Nara plant and pips.

Composition	Plant as is (fresh) mg/100g	Pips mg/100g
Carotene	0.12	
Thiamine	0.01	
Riboflavine	0.02	
NicotinicAcid	0.75	2.17
Ca	21.40	100.00
Mg	19.00	363.00
Fe	0.50	4.00
K	654.00	400.00
Cu	0.30	3.90
Zn	0.60	5.50
P	22.40	811.00
Na	14.10	3.00
	g/100g	g/100g
Protein	1.40	30.70
Fat	0.30	57.00
Ash	1.60	3.40
Moisture	84.00	5.30
Crude Fibre	1.00	1.30
Carbohydrate	11.70	2.30
Energy Value kJ	231	2709

By comparison, Grimmer (1910) found up to 46 % oil and 32 % protein in the pips.

General observations on study plants

Dunes Site

No plants died during the study period, although two lost condition. One unsexed plant was in fair condition at the beginning of the study, but deteriorated after nine months. This is reflected in the percentage of dead stems, which increased from 40 % to 90 % at the end of the study. Similarly, a female plant lost condition during the last nine months of the study period when the percentage of dead stems increased from 15 % to 80 %.

River Site

One plant had the highest recorded female flower production rate during September 1990. This plant (estimated ground surface area covered of 24 m²) grew about 30 m from the bank of the river, near the base of a dune, at an elevation of about 10 m above the riverbed. Fruit and tips of growing shoots were utilised by donkeys, indicated by fresh tracks and dung around the plant. One male plant died during the study period. Judging by the thickness of its stem it was a very old established plant,

growing close to the river. At the beginning of the study it was in good condition and produced flowers prolifically. However, its condition and rate of growth decreased slowly over the next 11 months when it appeared yellow and no new growth tips were observed. During the following four months it became brown in colour and eventually died. Another plant, a female, was virtually demolished by gemsbok trampling and feeding during the study period. Although vigorous new shoots appeared regularly, they did not grow higher than 20 cm during the remaining 22 months of the study.

Sandwich Site

During the last two monitoring visits in 1992 the condition of three plants in the southern section had deteriorated noticeably. In one male plant, the percentage of dead stems increased from 30 % to 95 %. This was probably caused by a rise in salinity due to severe attrition of the beach and changes of the mouth's location. Similarly, at the end of the study, all five plants monitored in the northern section of the site showed deterioration in condition due to an increase in salinity in the previously fresh-water pools.

Condition ratings

Rainfall did not seem to have had an influence on the condition of plants. From January to December 1990 the rainfall measured at Gobabeb was 12.3 mm (Henschel 1999) when nine male and 17 female plants were rated good. However, during 1991 the rainfall at Gobabeb was 50 % higher (18.3 mm, Henschel 1999) but only 10 male and 13 female plants were rated good.

A comparison of condition ratings in male and female plants ($n = 520$) between the three study sites showed that the River site ranked highest. A good condition was recorded 45 times at the River site, 11 times at the Dunes site but only once at the Sandwich site. Fifteen male plants and 30 female plants at the River site were rated good. Seven male and four female plants at the Dunes site showed a rating of good. At the Sandwich site no male plants attained a good condition and only one female plant attained a condition rating of good.

Condition ratings of male !Nara plants in the three study sites shows that they were in good condition in both the inland study sites, but poor in the Sandwich site where some plants deteriorated noticeably in condition during the study period. However, female plants were rated good in all three study sites. Increasing salinity at the coastal site and better quality ground water at the inland sites are possible reasons for the differences in the plants' condition.

This may have been caused by an increase in the salinity of the fresh-water system. Also, the River site probably had access to better quality water than the coastal and the Dunes sites.

Nara Valley

In April 1994 a survey was done at Nara Valley, an inter-dune valley approximately 15 km west of Gobabeb on the southern bank of the Kuiseb River. Nara Valley is surrounded by linear dunes of up to 100 m high (Louw *et al.* 1988), and stretches for about 4 km southwards. Approximately 250 !Nara plants grow in this valley. !Nara fruit are still being harvested by the local Topnaars who live in a few scattered, small settlements along the river. To establish the ratio between male and female plants, 11 east-west transects were done across the valley, which is slightly more than 1 km wide. In a sample area, starting at the southern riverbank and moving southwards, a total of 77 plants were counted: 42 females, 33 males and two that could not be sexed due to the absence of flowers. This ratio of 42 females to 33 males does not differ significantly from a 1:1 ratio ($\chi^2 = 0.2987$, 1 d.f., $P > 0.05$) Their estimated ground area covered ranged from approximately 3 m² to 154 m². The distances between the individual plants were not measured.

Summary and conclusions

This study took place during an average to below average rainfall period in the Central Namib. Water inputs into the Kuiseb River system were typically erratic, varying from 6 to 19 days of river flow annually. Presumably these flows benefited only those !Nara growing in close proximity to the riverbed, because their condition improved noticeably compared to !Nara located in the dunes. In comparison, coastal !Nara appeared to benefit directly from regular freshwater seepage under the dunes at Sandwich Harbour, which probably resulted in their high rate of fruit production.

Utilisation of fruit was higher in the inland River and Dunes sites than at the coast. This was due to the off-take by people and the feeding of donkeys, which came from nearby Topnaar settlements along the Kuiseb River. Donkeys roam freely through the !Nara fields. Furthermore, their hoof action on the !Nara plants causes further damage to growing stems. Moreover, the establishment of permanent, mechanically powered water points along the lower Kuiseb River has facilitated sedentary settlements of people and their domestic stock where previously their traditional lifestyle was largely nomadic.

The coastal !Nara at Sandwich Harbour, whilst free of off-take by humans and donkeys, were exposed to an unstable, rapidly changing environment in which erosion of the shoreline by wave action caused the ocean to encroach on their habitat. Despite a constant source of fresh water originating from under the dunes, the resultant increase in salinity, coupled with exposure of their root systems, subsequently killed some of the !Nara I had selected for monitoring. I observed entire !Nara plants and the dune hummocks on which they grew being destroyed by the receding shoreline. In the 10-year period that followed my study, I estimate that the sea has advanced as much as 100 m, reaching the base of the dunes where !Nara were

located. The effect of this dynamic coastline change has been the demise of the once flourishing !Nara communities in the northern lagoon of Sandwich Harbour.

My overall impression regarding the status of !Nara in the three sites I selected is that the inland !Nara have been subjected to an increase in fruit utilization by people and donkeys, whilst the coastal !Nara have suffered a severe setback following an unpredictable change in the unstable coastline. Because the episodic changes in the habitat at Sandwich Harbour are natural, no management of !Nara there is possible. However, at the inland sites I observed, control of domestic donkeys is advisable, because this area falls within the boundaries of the Namib-Naukluft Park, whose management plan prescribes definite strategies according to the zoning of the Park.

Pressure of humans and domestic stock along the Kuiseb River and adjoining dune valleys was evident by the amount of fruit eaten. Hoof action of especially donkeys resulted in further damage to growing stems.

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