REPORT

AQUATIC AND WETLAND PLANTS ASSOCIATED WITH THE OLUSHANDJA DAM

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EXECUTIVE SUMMARY

This study undertook a survey of aquatic and wetland plants associated with the Olushandja Dam. Time restricted the study to a description of the existing aquatic and wetland communities in the dam, listing of terrestrial species affected by the proposed rise of the water level and a brief investigation of possible invasive species brought in by the distribution canal from Calueque.

Since the establishment of the dam about 20 years ago, 5 aquatic communities have colonised the dam. Although some of the communities are not as species rich as communities in the closest comparable permanent wetland - the Okavango Delta - this is a remarkable biological diversity. Reedbeds, sedge communities, floating mats and floating-leaved vegetation make up the "true" wetland communities, which are permanently inundated. The seasonal changes in water level support a rich community of fringe vegetation, which is comprised of wetland as well as terrestrial species. Naturally adapted to seasonal changes in water level, none of the aquatic and wetland communities are expected to be negatively affected by a gradual rise in water level, provided that certain recommendations are followed.

To maintain or even augment the existing diversity (1) water levels should be increased gradually to allow the aquatic and wetland communities to adapt to the rising water level, (2) the water level in the dam should be kept at a nearly constant level and (3) an *in situ* conservation site should be proclaimed to protect wetland species.

The terrestrial fringes of the dam are heavily overgrazed. As a result the vegetation is impoverished with only a few unpalatable grazing indicators such as *Pechuel-Loeschea leubnitziae* remaining. An exception is a regional endemic and protected stem-succulent *Hoodia* species, which will be affected by a rise in water level and should be transplanted in advance.

Of possible economic importance is the tall emergent aquatic grass *Oryza longistaminata*, a relative of cultivated rice which may be used for breeding purposes. Reeds are expected to be used by the local communities for thatching and some of the dominant sedge species are edible. These plants should benefit from a rise in level provided that the water rises gradually and is kept at a nearly constant level.

No invasive plant species are present in the dam and the canal that brings water from the Calueque Dam. However, it is recommended that a vegetation survey of the Calueque Dam is carried out to ensure that there are no problem plants invading with the proposed increased water inflow.

Since information on phenology, growth and establishment of subtropical wetland plants is fragmentary, it is recommended to establish permanent plots to study the response of wetland vegetation to a rise in water level. This information will be useful in management decisions and future establishment of artificial water bodies.

1. INTRODUCTION

The Olushandja Dam is an artificial permanent water body situated within the ephemeral oshana wetlands in northern Namibia. Originally established in 1973 as an emergency water reservoir to supply the northern region, it has until now never reached its full capacity. The dam receives its inflow from the Calueque Dam in Angola, which is situated on the Kunene River about 12 km north of the Olushandja Dam. At present the Calueque Dam is only partly functional because of destruction during the war. However, repairs and upgrading of the pumping facilities at Calueque are in progress at the moment. This would allow an increase in water inflow to Olushandja Dam to the maximum rate of water abstraction sanctioned by the water agreement with Angola. The growing water needs in the northern Ovamoboland region make increased water abstraction rates desirable.

There are two major environmental concerns associated with the upgrading of the inflow to the Olushandja Dam:

(1) On a regional level, increased abstraction from the Kunene River will invariably affect the wetlands downstream from Calueque.

(2) On a local level, the potential spread of parasitic diseases and invasive alien plants as well as inundation of terrestrial habitats might bring about negative impacts on the health of human and ecological communities dependent on the dam.

This baseline study investigates the distribution of aquatic and wetland plants in and around the dam to determine the possible effects of an increased inflow and increased water level on these plant communities. The study forms part of an Environmental Impact Assessment of the Calueque-Olushandja upgrading scheme.

2. CHARACTERISTICS OF THE STUDY AREA

The dam is located on tertiary sand and calcrete deposits of over 10 m thickness (Geological Survey 1980). The climate in the region is subtropical, receiving an average of 493 mm rainfall per annum (measured over 83 years at Ondangwa, Weather Bureau). In the rainy season 1994/1995 (July-April) a total of 387 mm was recorded at the closest weather station (Ruacana) with major rains of 300 mm in February (Weather Bureau). Average daily minimum and maximum temperatures range from 15°C in winter to 31°C in summer and frosts are rare events (measured at Ondangwa over 41 yrs, Weather Bureau). The dam is positioned in a former ephemeral oshana, stretching 20 km in a north-south direction and 0.2 to 2 km in a west-east direction. The maximum water depth is about 3.5 m.

The surrounding natural vegetation is mopane savanna. However, the area is densely populated and in the vicinity of villages the woodlands have been largely cut down for firewood, building and fencing materials. The abundance of toxic or aromatic weedy species indicates overgrazing by goats, donkeys and cattle.

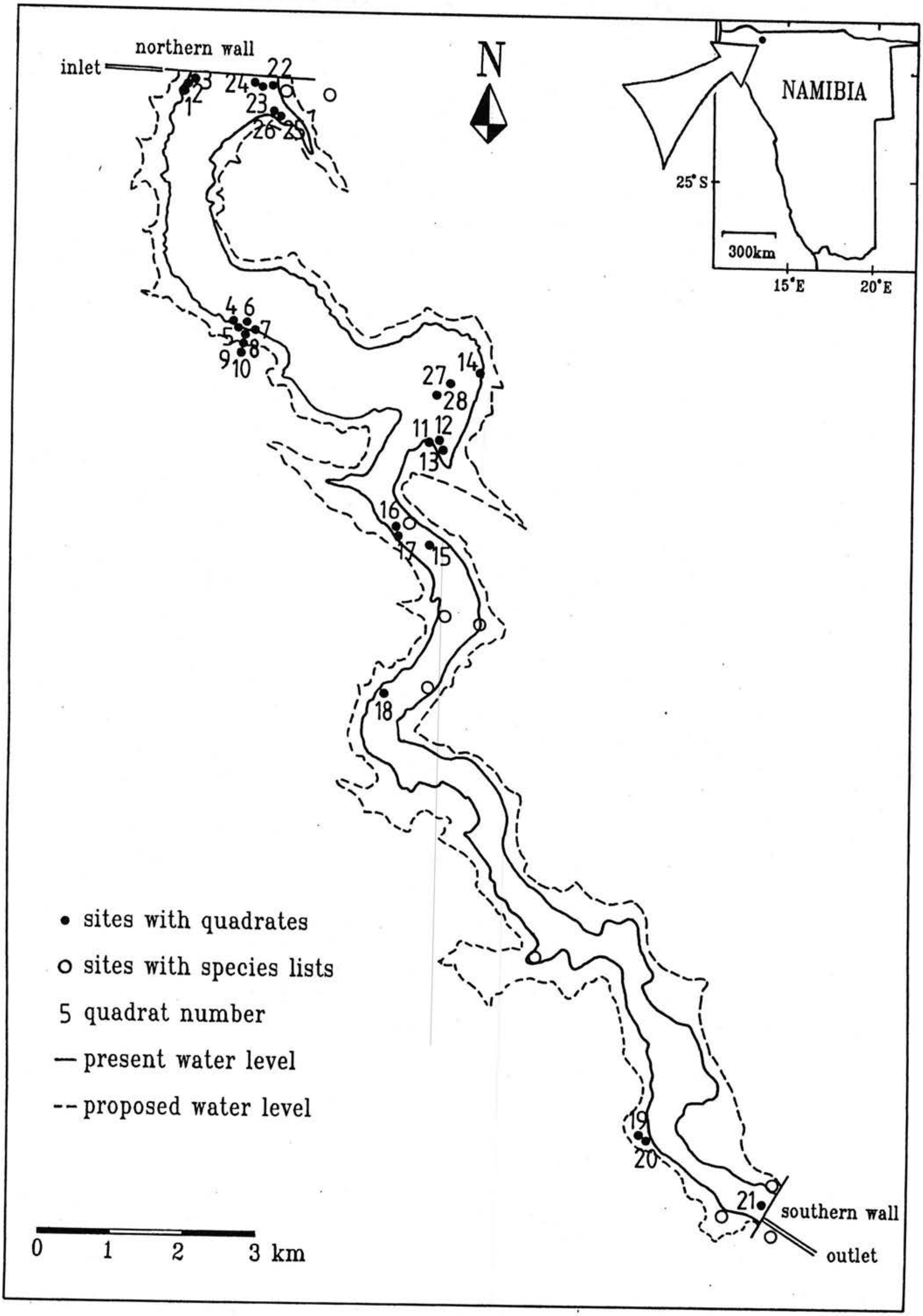

Fig. 1: Map of the study area and sampling sites of the botanical survey.

3. METHODOLOGY

Because of late rains in the region, the survey of aquatic, wetland and terrestrial plants associated with the dam was undertaken in the period of 19 to 26 April 1995.

The sites of the vegetation survey were selected to overlap as much as possible with the snail survey sites (see Curtis).

The plant communities, thus the sampling sites, were chosen according to dominant vegetation (eg. reed beds, floating mats, etc.) to represent all possible aquatic community types. All aquatic and wetland communities were located and sampled by setting up 1 to 3 quadrates of 5x5 m - a recommended size in wetland communities (Ellery *et al.* 1991) in each community. A total of 28 quadrates was recorded (Fig. 1). In each quadrat the total vegetation cover and the cover of each species was estimated according to the Braun-Blanquet method (Müller-Dombois & Ellenberg 1974). A voucher specimen of each species was taken for later identification and will be housed at the National Herbarium in Windhoek. In addition, the maximum height of each species was determined, as well as the growth form.

Descriptive notes about the habitat were taken, the water depth determined 3 times in each quadrat and the closest distance from the shore was measured. All plant species in the vicinity, which were not recorded within the quadrates were sampled to be added to the species list.

Concurrently a list of species of terrestrial plants that would possibly be inundated by increased water levels was compiled at each sampling site. In addition, a transect of 300 m length was established at the western shoreline from the current water level into the mopane woodland. Along the transect a list of plant species was compiled as well as a quadrat placed at roughly 100 m intervals. Vegetation cover, height and growth form were determined as above.

To investigate the possible introduction of invasive plants from the Kunene River and Calueque Dam, plant species were also collected along the distribution canal between the two impoundments. Because of construction works, only 3 km of the canal in the vicinity of Olushandja were in existence at the time of the survey. A brief investigation of plant species in and around the Calueque Dam would thus have been very useful. However, logistics as well as time constraints did not allow such an investigation.

Table 1: Variables determined within each quadrat.

(A) cover

r	one individual
+	several individuals, but < 1 % cover
1	1- 5 %
2	6-25 %
3	26-50 %
4	51-75 %
5	> 75 %

(B) height class (above water level)

1	0- 25 cm
2	26- 50 cm
3	51-100 cm
4	101-200 cm
5	> 200 cm

(C) habitat/growth form[1]

EA	emergent aquatic (rooted in water, but emerging above the water surface)
LFA	leaf-floating aquatic (plants rooted or free floating, but leaves always floating on the water surface)
RU	ruderal (terrestrial, weedy species)
SA	submerged aquatic (entirely below the water surface)
SFA	stem-floating aquatic (rooted in water, stems floating)
T	terrestrial
TI	terrestrial on islands
WA	wetland associated (growing in damp areas, usually around the edge of the water)

The identification of the plant material posed a major problem, since the collections of the National Herbarium are inaccessible at the moment and will only be available at the earliest by the end of 1995. I identified the plant species as far as possible, but I was unable to verify my entire collection by comparing the specimens with the national plant collection. Identifications of doubtful species and species of possible conservation importance were verified by staff of the Botanical Research Institute of Namibia. Nevertheless, 8 specimens could not be identified with certainty. They are marked "cf" in the appendix. Although by special arrangement I was able to use the national collections of the family Cyperaceae (sedges), 2 sedges could not be identified to species level. Unfortunately the limited time available for the project made it impossible to send plant material for identification to specialists elsewhere, to verify identifications and to clarify name changes. However, since I am familiar and aware of plant species with economic, conservation and possible invasive potential, my recommendations and conclusions should not be affected by corrections of plant names at a later stage. The nomenclature follows Arnold & de Wet (1993) and Kolberg *et al.* (1992).

[1] adapted from Bethune (1991)

Time also limited the analytical part of the study. A multivariate analysis of the plant communities, as well as mapping the different community types was impossible during the short time available. Thus I restricted the analysis to describing the different plant communities and the possible effect of a higher water level on these communities.

The plant species were classified according to their growth form/habitat (Table 1C) and geographic distribution (Table 2) to describe different ecological niches and to indicate species of high conservation status. Distribution classes were assigned according to "Plants of Southern Africa" (Arnold & de Wet 1993), "Prodromus einer Flora von Südwestafrika" (Merxmüller 1968) and own observations. Unfortunately distribution records of the national plant collection could not be incorporated for reasons mentioned above.

Table 2: Geographic distribution classes.

	description
i	introduced species
NE	endemic to Namibia
rE	regional endemic (Ovambo, Okavango, Kaokaland and Angola)
oS	occasional in southern Africa (< 4 South African provinces and/or countries)
sA	widespread in southern Africa (≥ 4 South African provinces and countries)

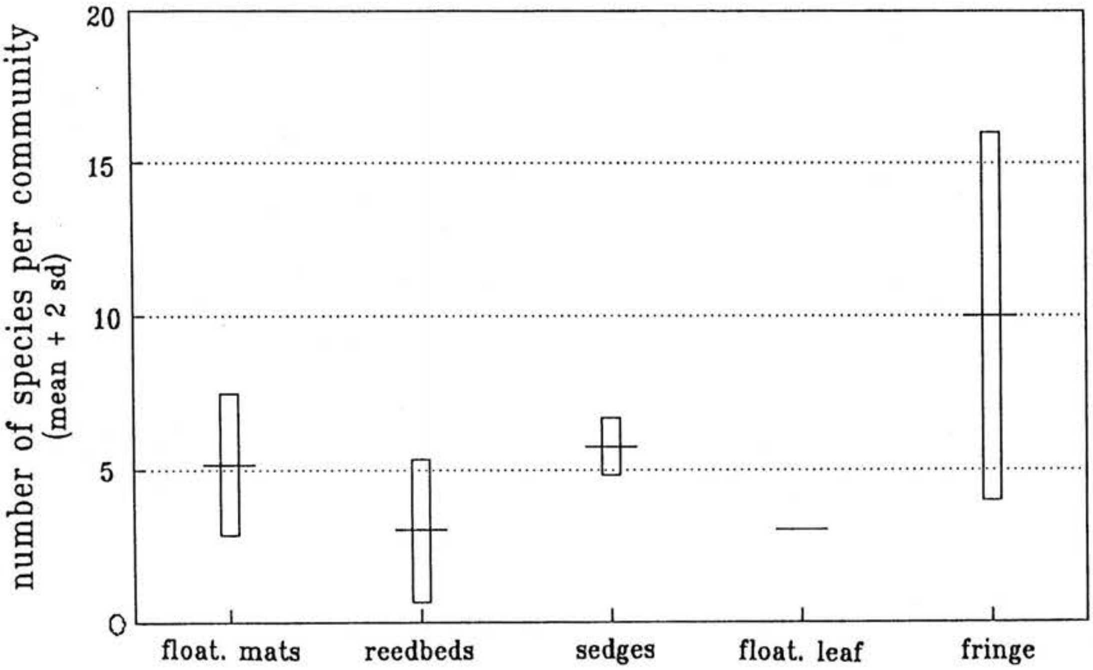

Fig. 2: Mean number and standard deviation (2 sd) of species per wetland and aquatic community in Olushandja Dam.

4. RESULTS AND DISCUSSION

4.1. Wetland and aquatic community types

Since the establishment of the dam about 20 years ago, five major aquatic and wetland community types have colonised the Olushandja Dam. A study in the Okavango Delta, for example, delimited 7 communities (Ellery *et al.* 1991), only two more than found in the Olushandja Dam. Comparing the extension and complexity of the Okavango Delta to Olushandja Dam the present communities in the dam present a biological diversity which should be maintained.

Although for presentation purposes these communities will be treated separately, they are often found in close proximity to each other and intermingling of communities is possible. However, other than in natural wetland systems (Hughes 1988; Dunham 1989) no strict zonation patterns can be found around the dam, but rather patchily distributed communities, dominated by a few species.

Aquatic plant communities are generally species poor, usually dominated by one to 5 species, or rarely up to 17 species (Ellery *et al.* 1991). This can be attributed to the fact that many aquatic plant reproduce vegetatively forming massive clones of few individuals. This is especially the case with reed and sedge species (*Phragmites, Typha, Cyperus*), but also some stem-floating species, such as *Ludwigia stolonifera*.

Table 3: Sampling sites of particular community types (location see Fig. 1).

community type	quadrat number
floating mats	1, 4, 13, 16, 25, 26
reedbeds	15, 21, 24, 27, 28
sedge communities	2, 5, 22, 23
floating-leaved vegetation	11, 12
fringe vegetation	3, 6, 7, 14, 17, 18

The following communities can be recognised:

4.1.1. Floating mats

Floating mats are plant assemblages dominated by aquatic plants with stem-floating growth form (Photo 1). In the Olushandja Dam *Ludwigia stolonifera* (Photo 2) is the most prominent plant species, often accompanied by emergent aquatic sedges such as *Cyperus imbricatus* and emergent aquatic perennials which are rooted in the floating mats. *Ludwigia octovalvis* ssp. *brevisepala* and cf. *Adenostemma caffrum* are the most common emergent aquatic perennials associated with this community. An average of 5 species was recorded (Fig. 2), which is similar in number to what was found in a study in the Okavango delta, although the species differed (Ellery *et al.* 1991). *Ludwigia stolonifera* is rooted in the ground, but produces long runners which form dense mats. Occasionally sedge species such as *Courtoisina assimilis* and *Cyperus pectinatus* as well as young *Phragmites* plants root in these mats. *Ludwigia stolonifera* is adapted to changing water levels, because it also found growing on land in the vicinity of the shoreline.

Floating mats usually develop close to the shore (0-10m), only in sheltered bays reaching as far as up to 30 m into the water. Average water depths within this community range between 15 and 45 cm and they are rooted in this shallow water. Wave action further away from the shore, as well as greater depths might restrict the development of large mats. Within the dam, floating mats are the most widely distributed community type and patches occur all around the dam, although they are more concentrated in the northern part of the dam. They are shelter and nesting sites for a variety of aquatic and wetland insects, reptiles, snails and birds. Larvae of dragonflies and snails, in turn, are a food source for fish. Fish also lay their eggs on these aquatic plants. The floating mats might also help to reduce wave action along the margins, thus increasing the clarity of the otherwise turbid water in the most parts of the shallow dam.

Although floating mats are adapted to seasonal changes in water level, water should be raised slowly to allow reestablishment of new mats along the new margins.

4.1.2. Reedbeds

Reedbeds are found at several places along the shoreline as well as in the centre of the dam. The latter are usually associated with termite mounds which are partially or totally covered by the present water level. In most cases the reedbeds form uniform stands of either *Phragmites mauritianus* or *Typha capensis* (Photo 3), two common reed species in southern Africa. Species numbers are low (Fig. 2). Since *Phragmites* reedbeds can reach heights of up to 5 m, they form very prominent features in the dam. Reedbeds consisting of *Typha* are usually slightly lower, reaching up to 3.5 m in height. Occasionally reedbeds consisting of the sedge *Cyperus articulatus* occur, which are smaller in extent and in height (up to 2 m). Species forming reedbeds are rooted in the ground and show the highest tolerance to flooding (Ellery *et al.* 1993). The average water depth of these communities ranges from 50 to 120 cm.

Reedbeds grow near the northern and southern dam wall as well as in the central parts of the dam. A number of bird species, such as Red Bishops (*Euplectes orix* L.), use these for nesting sites. Normally reedbeds are found along the margins of rivers and standing waters, but hardly ever in the centre of a large water body. The reedbeds in the middle of the Olushandja Dam can be considered a special habitat which is worth protecting, since it is a refuge for birds away from the water's edge which is often frequented by people. In areas with water pollution problems reedbeds are often used as natural filters to purify water.

Reed species are naturally adapted to tolerate permanent flooding and changes in water table (Ellery *et al.* 1993). Provided that changes in the water level do not occur suddenly the reedbeds in the Olushandja Dam will be able to colonise new habitats such as termitaria which are presently terrestrial.

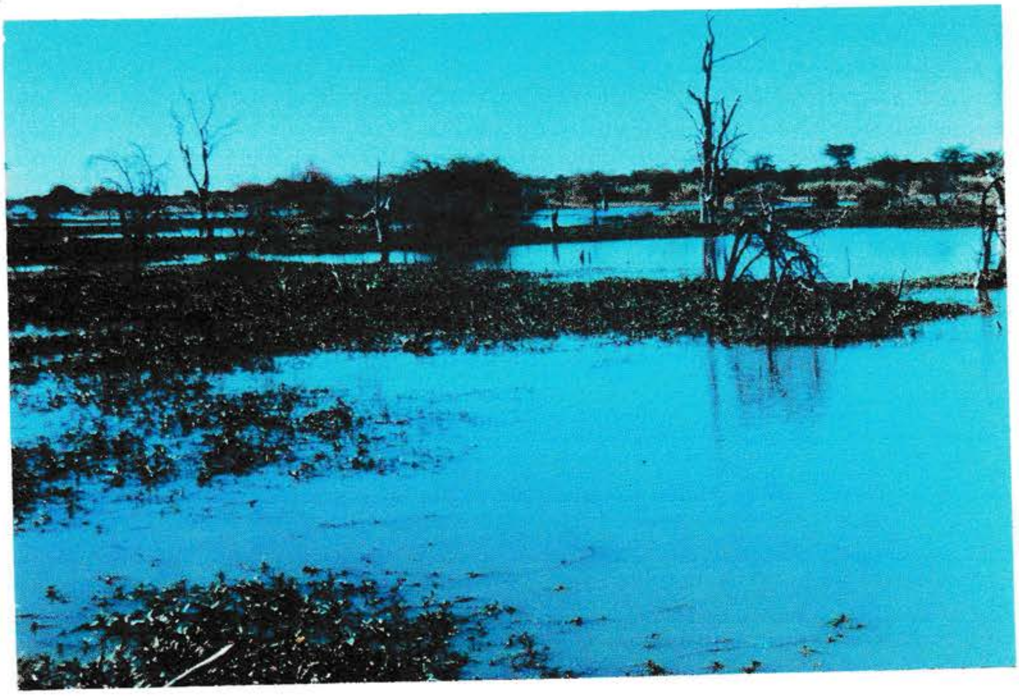

Photo 1: Floating mats are mainly comprised of *Ludwigia stolonifera*.

Photo 2: *Ludwigia stolonifera* is the most abundant aquatic plant in Olushandja Dam.

Photo 3: Typical reedbed with *Typha capensis*.

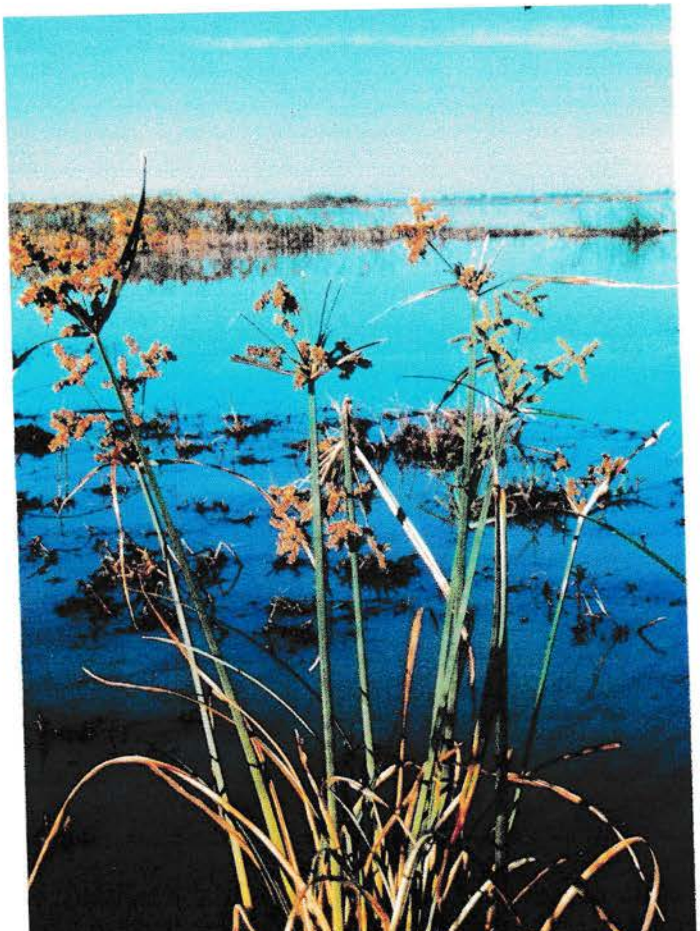

Photo 4: *Cyperus imbricatus* is the most dominant sedge species around the dam.

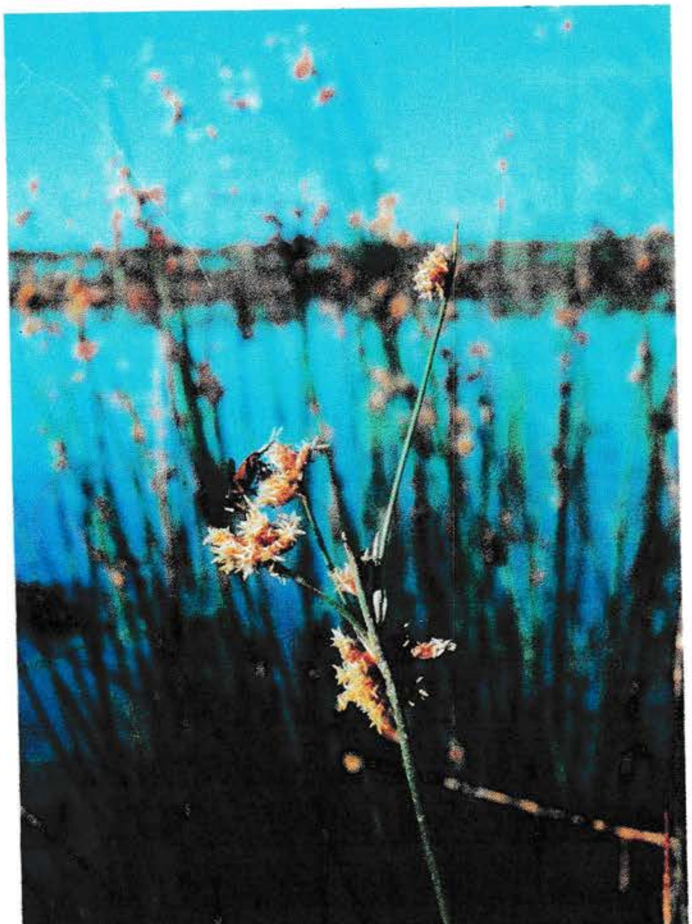

Photo 5: Even sedges attract pollinators: here *Schoenoplectus corymbosus* is visited by a large fly harvesting nutritious pollen.

4.1.3. Sedge communities

The most prominent sedge communities in Olushandja Dam reach heights up to 1.5 m and mainly consist of *Cyperus imbricatus* (Photo 4) and *Schoenoplectus corymbosus* (Photo 5). Accompanying species are *Bolboschoenus nobilis*, a Namibian endemic, the submerged *Utricularia gibba* (Photo 6) and *Ludwigia stolonifera*. Growing in the vicinity of the shoreline, but rooted in the water, sedge communities colonise water depths of 5 to 35 cm on average. They usually do not exceed distances of 10 m from the shoreline. The average number of species in this community (Fig. 2) reaches about half of the number of species recorded in the Okavango Delta (Ellery *et al.* 1991). Apart from *S. corymbosus*, the species composition also differs between Olushandja Dam and the Okavango Delta. This might be explained since sedge communities are usually late successional plant communities, which require long, undisturbed periods to develop (Ellery *et al.* 1993).

Sedge communities are scattered around the dam, usually at sheltered places, but like the floating mats are more frequent in the northern part of the dam. Besides providing nesting sites, food and shelter for aquatic animals (fish, reptiles and insects), their filtering effect can be useful to help purify polluted water (Brix 1994).

4.1.4. Floating-leaved vegetation

Although floating-leaved species occur in other communities as accompanying species, they also form uniform stands in some parts of the dam, with an average of 3 species within this community (Fig. 2). *Nymphoides indica* (Photo 7) and *Ludwigia stolonifera* are the dominant species in this community interspersed by tall sedges such as *Cyperus imbricatus* and *Schoenoplectus corymbosus*. At average water depths of 30 cm the floating-leaved vegetation extends up to 25 m from the shore into the water. Wave action restricts the distribution of *Nymphoides* to few sheltered places along the eastern shore and makes it the rarest of the aquatic communities. As the name indicates the floating-leaved vegetation drifts on the water, thus will not be affected by a rise in water level.

4.1.5. Fringe vegetation

At the interface of water and land diverse assemblages of wetland-associated species occur (Photo 8). Subjected to often rapidly receding water levels, species growing at the dam margin either have to tolerate a wide range of conditions from submerged to exposed or they are short-lived, fast growing annuals. These germinate rapidly once the water level starts receding after the rainy season and complete their life cycle before the margins have entirely dried out. *Cynodon dactylon* is one of the grass species which occurs all around the dam. Adapted to seasonal flooding and a common floodplain grass, it grows quickly when the water rises and dies back when the water level drops again (Heeg & Breen 1982; Bethune 1991). Other frequently encountered species around the dam margin are *Ludwigia stolonifera*, which grows in damp areas on land as well as floating in the water, the slightly succulent creeper *Ammannia baccifera* (Photo 9) and the sedge *Cyperus compressus*. Compared to the purely aquatic communities, the fringe vegetation

Photo 6: The submerged *Utricularia gibba* produces only flowers above the water surface.

Photo 7: Floating-leaved vegetation in the dam consists of the "false water lily" *Nymphoides indica*.

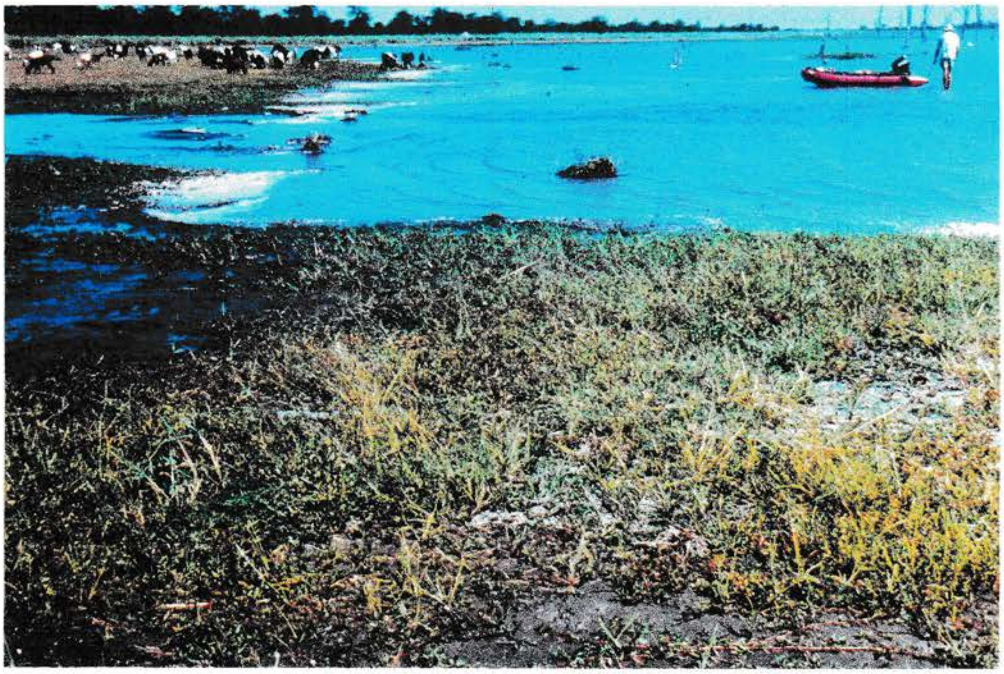

Photo 8: Because of seasonal change in the water level, the fringe vegetation is either short-lived or tolerates a wide range of environmental conditions.

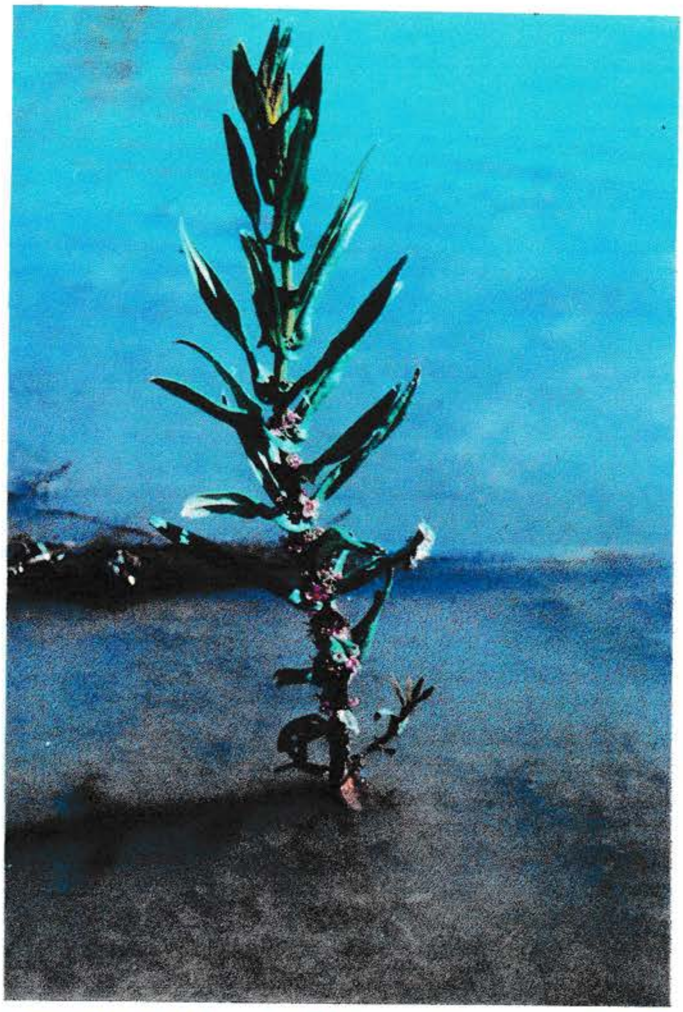

Photo 9: The attractive annual *Ammannia baccifera* is heavily browsed and trampled by livestock, thus hardly ever grows erect, but creeps along the ground.

Photo 10: A population of the endemic *Hoodia* cf. *parviflora* is threatened by an increased water level and should be transplanted.

Photo 11: *Bergia spathulata* is an attractive, regional endemic usually associated with wetlands.

is much more diverse, since wetland associated and terrestrial species occur together (App. I). An average of 10 species was found in this community (Fig. 2).

Since the majority of the fringe vegetation are short-lived annuals adapted to changing water levels, they will be able to colonise new margins, if the water level rises. At present these communities are subjected to severe trampling and grazing, especially in the vicinity of villages, which is gradually changing their habit and composition to few low growing, unpalatable species. A rise in water level could have two contrasting effects on the fringe vegetation: in areas where the proposed water level will move closer to habitations, the fringe vegetation may suffer more severe pressure by grazing and trampling than at present. Where the proposed water level inundates present settlements, the negative human impact may be removed and may help the re-establishment of new fringe vegetation.

4.2. Terrestrial communities

Although vegetation was recorded along a transect extending 20 km west from the western shore, I will concentrate here on the vegetation which might be inundated by a rise in water level. At present the vegetation surrounding the dam is overutilized for grazing, cutting of fuel wood and fencing. Accordingly the entire margin of the dam shows five distinct zones of different levels of utilization.

From the current water level the fringe vegetation extends up to 5 m inland, depending on the slope of the shore and season (Fig. 3). This damp belt is followed by a zone of about 15 - 20 m width, dominated by terrestrial grasses and herbs, and occasional *Acacia nilotica* and *Acacia hebeclada* spp. *tristis*. A belt of about 100 m width dominated by *Pechuel-Loeschea leubnitziae* follows. It is an aromatic, unpalatable shrub which unmistakably indicates heavy overgrazing. The next zone is about 200 m wide and is characterized by coppiced *Colophospermum mopane* (mopane). It is interspersed with grazing indicators, such as *Geigeria ornativa*. Natural mopane woodland follows this zone.

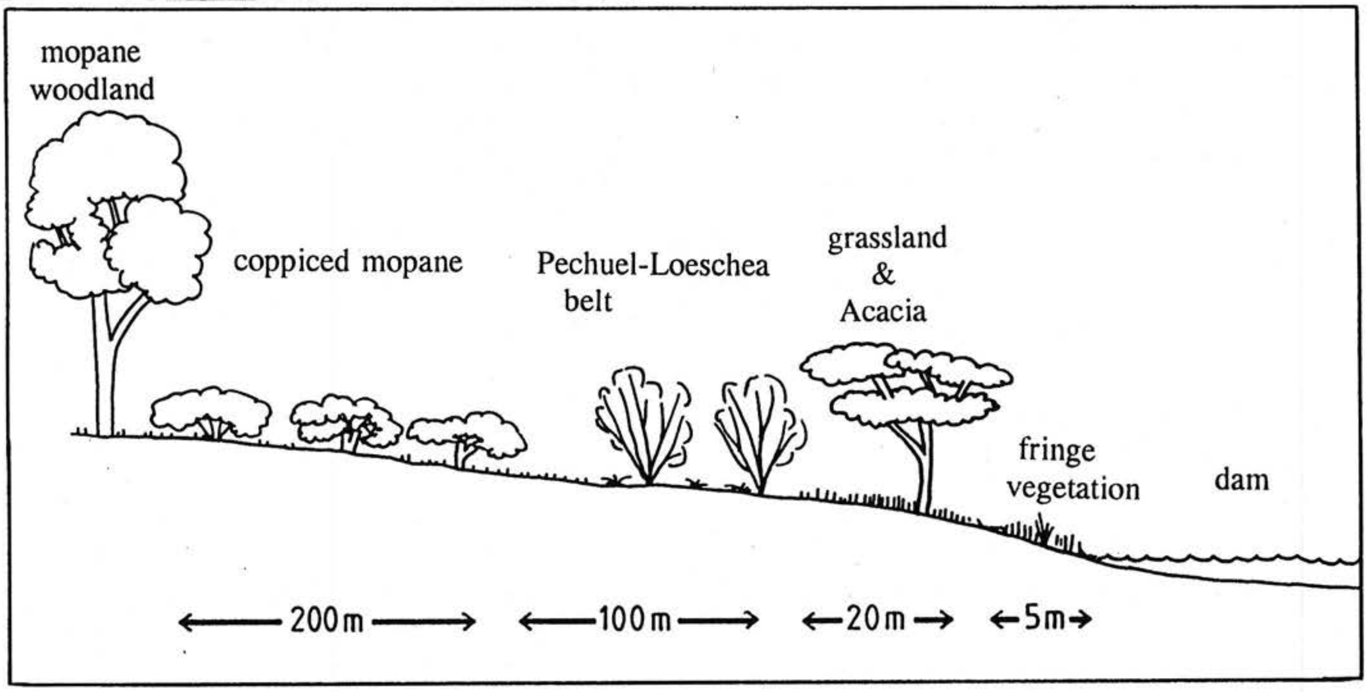

Fig. 3: Zonation of terrestrial vegetation around Olushandja Dam. (The illustration is not to scale.)

A rise in water level will thus not destroy any rare wetland associated communities, but might even improve the vegetation pattern by flooding some of the unpalatable grazing indicators. The future water level will not reach the natural mopane woodland. However, about 20 individuals of the stem-succulent *Hoodia* cf. *parviflora* (Photo 10), which is a protected species, occur in the southeastern corner of the dam. These would be inundated by a rise in water level and transplanting of at least part of the population should be considered. *Hoodia* species have successfully been transplanted in the past (H. Kolberg, pers. comm.) and young individuals of the spiny succulent could easily be handled in transplants.

4.3. Islands

Special habitats within the dam are the islands associated with termite mounds. Some of these harbour dense reed beds, others are inhabited by *Acacia* and mopane trees. Since these will invariably be flooded by a rising water level, 5 of these islands were investigated for rare wetland species. However, besides the reeds and trees, only common herbs, some of which are weedy (*Amaranthus thunbergii* and *Setaria verticillata*) were found on these islands. Their inundation will therefore not affect the status of any valued plant communities. Termitaria which are currently entirely terrestrial may substitute those which are going to be inundated with a rise in water level. New island habitats will thus be formed.

In addition, to substitute the loss of these special habitats, small banks could be bulldozed around *Acacia* species which are presently close to the water edge and which will be inundated when the water level has risen (see report Research Division, Department of Water Affairs).

4.4. Species of economic and conservation importance and problem plants

4.4.1. Biodiversity and conservation potential

A total of 120 plant species was recorded in this rapid survey in and around Olushandja Dam (App. II). Two species are endemic to Namibia (Fig. 4). *Bolboschoenus nobilis* is a sedge, thus a wetland species, which only occurs in this area because of the presence of the dam. *Solanum rigescentoides* is a terrestrial species which might be negatively affected by a rise in water level. However, the spiny shrub has a wide distribution range within Namibia, thus even flooding the entire population would not be a serious problem. The Olushandja Dam and its surroundings harbour 9 regional endemic plant species (endemic to northern Namibia, Okavango swamps and Angola), one of which is protected species and has thus a high conservation status. *Acacia hebeclada* ssp. *tristis*, *Adenium boehmianum*, *Merremia multisecta* and *Sesbania microphylla* are terrestrial species which might be affected by a rise in water level. Yet they are not uncommon in the region thus flooding of some individuals will not be a problem. *Hoodia* cf. *parviflora*, in turn, is a protected species with a possibly narrow distribution range. As pointed out above, transplants of young individuals of a population in the southeastern corner of the dam, which will be inundated, should be considered. The remaining regional endemics, *Bergia spathulata*, *Lagarosiphon ilicifolius*, *Mariscus hamulosus* and *Marsilea* cf. *unicornis* are wetland plants. A slow rise in water table and maintaining a fairly constant water level will result in more available habitats and will thus have a positive effect on the present populations.

Despite heavy grazing pressure by livestock around the dam, the present diversity of habitats and plant species has high conservation potential. Besides plant species of economic value for the local population (e.g. reeds and sedges), diverse communities of wetland species are safe breeding grounds for fish which in turn can be utilized by the local communities. Thus the establishment of a conservation site is recommended which will not only enable the wetland and fringe vegetation to develop, but will also benefit the local communities by providing breeding places for fish. Besides preserving the present wetland communities, the conservation site could also be used as a sanctuary for rare wetland species which occur in this region. However, introduction of indigenous rare species from the vicinity, e.g. the oshanas, should only take place by sowing of seeds or after a quarantine period under greenhouse conditions to ensure that no invasive, alien species are introduced with the indigenous plants.

4.4.2. Species of economic importance

Of possible economic importance for breeding purposes is the tall emergent aquatic grass *Oryza longistaminata*, a relative of cultivated rice. It was only recorded once in the dam, but might hopefully expand its population, if the water surface is increased.

Besides livestock which has been observed to graze in some of the sedge communities (K. Roberts, pers. comm.), the local residents are expected to utilize the wetland vegetation, e.g. reeds for thatching (Rodin 1985). Although an ethnobotanical survey was beyond the scope of this study, people were occasionally observed picking *Cyperus imbricatus*, the dominant sedge, which has got an edible stem (K. Roberts, pers. obs.). Other plants species might also be utilized as food source, medicine and building material. These aspects need further investigations.

4.4.3. Problem plants

No invasive species were recorded in the dam and the distribution canal, but an investigation of Calueque Dam is recommended.

At present eutrophication and a subsequent increase in plant biomass does not pose a threat to the ecological balance or to the water pumps, which can get obstructed by plant material. Nevertheless, vegetation should be removed in the vicinity of the pumps.

4.5. Research and educational needs

The importance of wetlands in Namibia has been recognised only recently (Simmons *et al.* 1991). Consequently Namibian wetlands are poorly understood (Breen 1991). Many practical questions related to management of natural and artificial wetlands arose in this study. These could be answered in future, if long-term observations in permanent plots are carried out.

Little is known about the life cycle of Namibian wetland plants. Yet for management purposes it would be imperative to know when is the main growing season of these plants, whether and when they produce seeds and how easily they establish from seeds. In addition, which environmental and biotic factors control germination, growth and establishment of wetland plants is essential information to guarantee success of planting efforts (Chambers & Mccomb 1994). Allelopathic interactions, for example, have been reported in many aquatic plants, inhibiting germination and growth of their neighbours (Elakovich & Wooten 1995). On the other hand, many wetland species form mycorrhiza, which might enhance their establishment potential (Rickerl *et al.* 1994). Nothing is known about Namibian wetland plants in this respect.

Permanent wetlands naturally experience fluctuations in water level. Thus wetland plants are adapted to changes in water depths and different periods of inundation, which both make up the water regime (Rea & Ganf 1994). However, which water regimes Namibian wetland plants can tolerate is speculative at present. Although the flooding regime has been recognised to be the most important variable determining the composition of wetland plant communities in southern Africa, edaphic factors can also play an important role (Coetzee & Rogers 1991). Knowing the specific requirements and tolerance levels of our indigenous wetland flora will be useful in recommendations for future establishment of artificial wetlands, such as dams (e.g. the proposed hydroelectric scheme at Epupa), and for management purposes.

Monitoring representative wetland communities in Olushandja Dam during the gradual rise of the water level might thus provide important information on tolerance levels and re-establishment potential of these communities. These permanent plots could be linked with the establishment of an *in situ* conservation site and part of straight-forward monitoring exercises could involve the local communities in form of projects in an environmental education programme. Fixed point photography could also be used in these monitoring programmes.

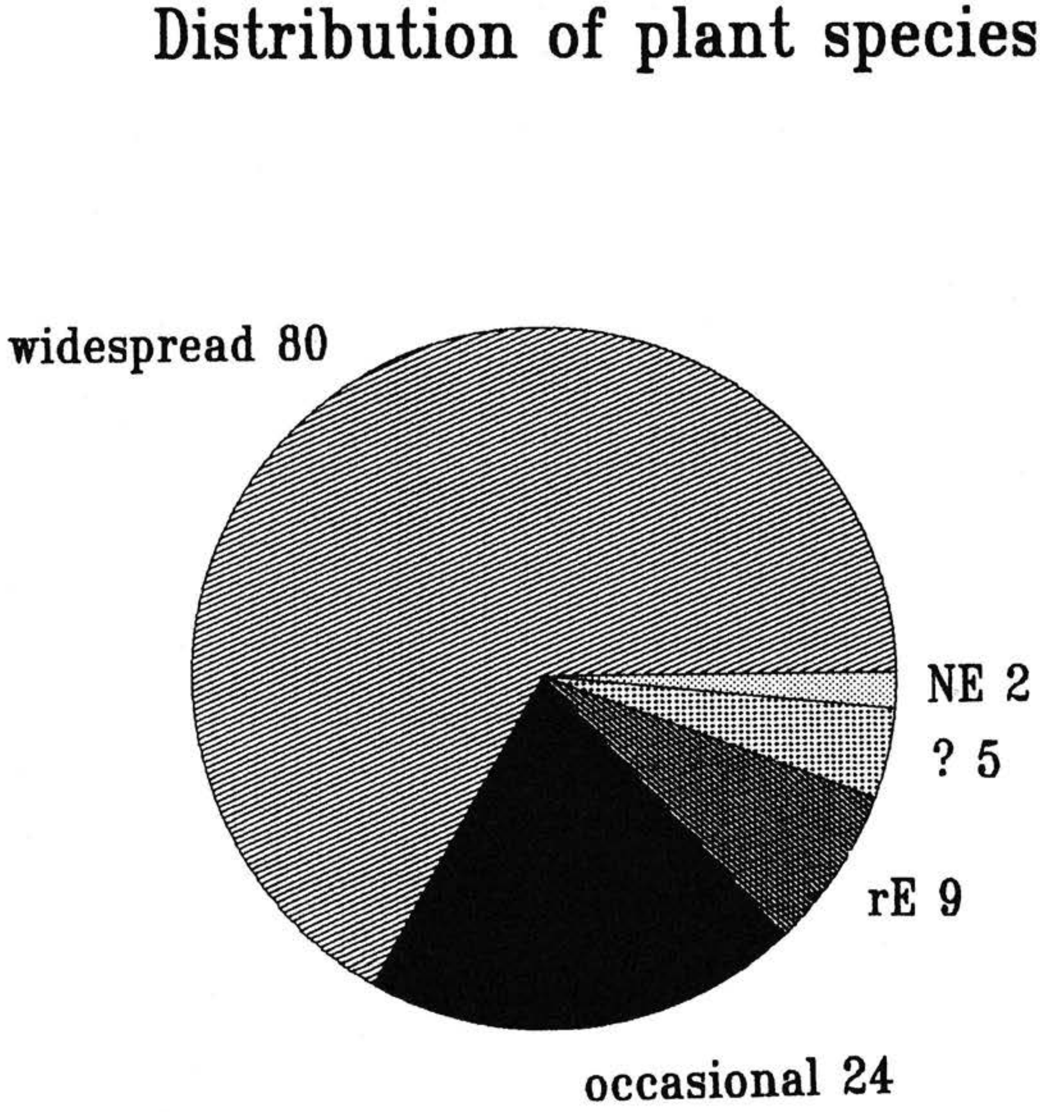

Fig. 4: Geographic distribution of aquatic and terrestrial plant species recorded in and around Olushandja Dam (NE = Namibian endemic, rE = regional endemic, occasional = occasional in southern Africa, widespread = widespread in southern Africa).

5. RECOMMENDATIONS

1. **Expanding the current survey to the Calueque Dam** will be imperative to find out about the origin of the present wetland and aquatic species in Olushandja Dam and to predict their future development. An expanded survey will also allow definite conclusions to be drawn about the **possibility of invasive weeds colonising Olushandja Dam**.

2. From the current observations I do not foresee negative effects on the aquatic and wetland associated plant communities with an increased water level in Olushandja Dam, provided that certain aspects are taken into account:

A) If the current inflow rates are to be increased care should be taken to raise the water level slowly (> 1 year between present and future water level) to give plant and animal communities a chance to adapt and recolonise new areas.

B) Once the future dam level has been reached, the water level should be kept nearly constant (fluctuations < 30 cm), to ensure that plant and animal communities are only exposed to the seasonal fluctuations of the water level.

This is especially important considering that many aquatic and wetland species are clonal, thus reproduce vegetatively and rarely by means of seeds. Thus inflow and abstraction rates have to be calculated carefully and should also take the high losses through evaporation in the summer months into account (see report of the Research Division, Department of Water Affairs).

3. Raising the water level might on the other hand open the opportunity to study colonisation processes and successional phases in subtropical wetland communities and provide important information for management of natural and artificial wetlands. **For this purpose I recommend to set up permanent plots to monitor changes at regular intervals.** These permanent plots could be linked with the conservation site suggested below.

4. At present, the Olushandja-Calueque impoundments are the only permanent, standing waters in about 700 km radius (excluding Etosha Pan, which harbours a flora and fauna adapted to saline conditions). As the current study shows, despite heavy utilisation of the dam and its surroundings, some endemic aquatic and wetland associated species have colonized the dam and a variety of communities have established themselves. The present diversity of habitats and associated species should be maintained or even augmented. This could be achieved by keeping the water level fairly constant, and establishing a sanctuary for rare, endemic wetland species, introduced for example from the surrounding oshanas.

I recommend that part of the dam be declared as an *in situ* conservation site (Brindley 1992) for wetland species. This would also give the fringe vegetation a chance to recover. Other species which are currently eliminated by heavy grazing might colonize the area. In these conservation sites access should be controlled and grazing entirely excluded. The central part of the dam which harbours the highest diversity of habitats and wetland communities could be a suitable site. Further investigations are needed to determine the exact locality and whether and which wetland species could be established additionally. The creation and the nature of such a conservation site has to be implemented by the Ministry of Environment and Tourism in consultation with the local communities. Besides for research purposes this conservation site could also be used as a venue for a much needed environmental education centre in this region. Aspects of wetland ecology, as well as health education (e.g. the risks of bilharzia and ways to combat it) could be part of a programme offered at such an environmental education centre. Thus maintenance and control of the conservation site could be responsibility of the staff of the education centre. Donor agents should be approached for initial funding, while the maintenance could be a joint responsibility between the Ministry of Environment and Tourism, the Ministry of Education and the Ministry of Health.

5. On the terrestrial side the southeastern corner of the dam harbours a population of a protected, **regional endemic *Hoodia* species which is worth preserving and should be transplanted prior to raising of the water level.**

6. CONCLUSION

The Olushandja Dam harbours diverse aquatic and wetland associated plant communities some of which contain regional endemic species. These communities are well worth maintaining for ecological, educational and commercial reasons. Thus the water level should be increased gradually and then kept constant to ensure that the communities are not affected negatively. Parts of the dam area should be preserved as a conservation site for wetland species, chiefly for educational and research purposes. Here permanent plots, set up prior to the rise in water level and monitored at regular intervals could provide much needed information on the recovery and establishment potential of Namibian wetland vegetation. On the terrestrial side several individuals of a protected *Hoodia* species might be inundated. These could be preserved by transplanting them.

However, the affect of an elevated water level in Olushandja Dam is only one of the environmental concerns. An increased abstraction of water from the Kunene, thus a reduced flow downstream of Calueque will have a much wider ranging impact on aquatic and riverine flora and fauna along the Kunene and has to be investigated thoroughly.

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9. APPENDIX

APPENDIX I: Wetland associated and terrestrial species occurring in fringe vegetation around Olushandja Dam.

cf. *Adenostemma caffrum*
Aizoon canariense
Ammannia baccifera ssp. *baccifera*
Bergia spathulata
Bulbostylis hispidula
Chloris virgata
Corchorus tridens
Courtoisina assimilis
Cynodon dactylon
Cyperus compressus
Cyperus difformis
Dactyloctenium aegyptium
Echinochloa crus-galli
Eragrostis cylindriflora
Eragrostis porosa
Gomphrena celosoides
Isolepis hystrix
Kohautia caespitosa ssp. *brachyloba*
Ludwigia stolonifera
Mariscus hamulosus
Marsilia cf. unicornis
Osteospermum sp.
Schoenoplectus praelongatus

APPENDIX II: List of aquatic and terrestrial plant species found in and around Olushandja Dam, northern Namibia. (habitat: EA emergent aquatic, LFA leaf-floating aquatic, RU ruderal, SA submerged aquatic, SFA stem-floating aquatic, T terrestrial, TI terrestrial on islands, WA wetland associated (see Tab. 1C); dist = distribution: i introduced, NE endemic to Namibia, rE regional endemic, oS occasional in southern Africa, sA widespread in southern Africa (see Tab. 2).

species	family	habitat	dist
Abuliton pycnodon Hochr.	Malvaceae	TI	oS
Abuliton rehmannii Bak.f.	Malvaceae	T	sA
Acacia arenaria Schinz	Fabaceae	T	oS
Acacia hebeclada DC. ssp. *tristis* (Welw. ex Oliver) A.Schreiber	Fabaceae	T	rE
Acacia karroo Hayne	Fabaceae	T	sA
Acacia nilotica (L.)Willd. ex Del. spp. *krausiana* (Benth.)Brenan	Fabaceae	T	sA
Acacia tortilis ssp. *heteracantha* (Burch.)Brenan	Fabaceae	T	sA
Acrotome inflata Benth.	Lamiaceae	T,RU	sA
Adenium boehmianum Schinz	Apocynaceae	T	rE
cf *Adenostemma caffrum* DC.	Asteraceae	EA	sA
Aeschynomene indica L.	Fabaceae	T	sA
Aizoon canariense L.	Aizoaceae	WA	sA
Amaranthus thunbergii Moq.	Amaranthaceae	T,RU	sA
Ammannia baccifera L. spp. *baccifera*	Lythraceae	EA,WA	sA
Anthephora schinzii Hack.	Poaceae	T	sA
Aristida hordeacea Kunth	Poaceae	T,RU	oS
Aristida cf *stipitata* Hack. ssp. *stipitata*	Poaceae	T	sA
Bergia spathulata Schinz	Elatinaceae	WA	rE
Blumea cafra (DC.)O.Hoffm.	Asteraceae	T,RU	sA
Bolboschoenus nobilis (Ridley)Goetghebeur & Simpson	Cyperaceae	EA	NE
Bulbostylis humilis (Kunth)C.B.Clarke	Cyperaceae	WA	oS
Bulbostylis hispidula (Vahl) R.Haines	Cyperaceae	WA, T	sA
Burnatia enneandra P.A.Mich.	Alismataceae	SFA	sA
Ceratophyllum demersum L. var. *demersum* forma *demersum*	Ceratophyllaceae	SA	sA
Chamaecrista absus (L.)Erwin & Barneby	Fabaceae	T	oS
Chamaesyce hirta (L.)Millsp.	Euphorbiaceae	WA	sA
Chamaesyce inaequilatera (Sond.)Sojak	Euphorbiaceae	T,RU	sA
Chloris virgata Swartz	Poaceae	T,RU	sA
Colophospermum mopane (Kirk ex Benth.)Kirk ex J.Leonard	Fabaceae	T	sA
Conyza bonariensis (L.)Cronq.	Asteraceae	T,RU	sA,i
Corallocarpus welwitschii (Naud.)Hook.f. ex Welw.	Cucurbitaceae	T	oS
Corchorus tridens L.	Tiliaceae	WA	sA,i

species	family	habitat	dist
Courtisina assimilis (Steud.)P.Maquet	Cyperaceae	EA	sA
Crotalaria sphaerocarpa Perr. ex DC. spp. *sphaerocarpa*	Fabaceae	T	sA
Cucumis africanus L.f.	Cucurbitaceae	T	sA
Cynodon dactylon (L.)Pers.	Poaceae	T,RU	sA
Cyperus articulatus L.	Cyperaceae	EA	sA
Cyperus compressus L.	Cyperaceae	EA	sA
Cyperus difformis L.	Cyperaceae	EA	sA
Cyperus digitatus Roxb. ssp. *auricomus* (Sieber ex Spreng.)Kückenth.	Cyperaceae	EA	sA
Cyperus imbricatus Retz.	Cyperaceae	EA	sA
Cyperus pectinatus Vahl	Cyperaceae	SFA	sA
Dactyloctenium aegyptium (L.)Willd.	Poaceae	T,RU	sA
Dicoma anomala Sond.	Asteraceae	T	sA
Diplachne cuspidata Launert	Poaceae	WA	sA
Echinochloa crus-galli (L.)Beauv.	Poaceae	WA,SFA,TI	sA
Elytrophorus globularis Hack.	Poaceae	WA	sA
Enneapogon cenchroides (Roem.& Schult) C.E.Hubb.	Poaceae	T,RU	sA
Eragrostis bicolor Nees	Poaceae	T	sA
Eragrostis cylindriflora Hochst.	Poaceae	T	sA
Eragrostis porosa Nees	Poaceae	T	sA
Eragrostis viscosa (Retz.)Trin.	Poaceae	T	sA
Fuirena ciliaris (L.)Roxb. var. *ciliaris*	Cyperaceae	WA	sA
Galenia papulosa (Eckl.&Zeyh.) Sond. var. *papulosa*	Aizoaceae	T,WA	oS
Geigeria acaulis Benth.& Hook.f. ex Oliv.& Hiern	Asteraceae	T	oS
Geigeria ornativa O.Hoffm.	Asteraceae	T,RU	sA
Gisekia africana (Lour.) Kuntze var. *africana*	Aizoaceae	WA,T	sA
Gomphrena celosioides Mart.	Amaranthaceae	T,RU	sA,i
Heliotropium supinum L.	Boraginaceae	T	sA
Helichrysum cf. *lineare* DC.	Asteraceae	T	sA
Hermannia cf. *depressa* N.E.Br.	Sterculiaceae	WA,T	sA
Hermannia modesta (Ehrenb.)Mast.	Sterculiaceae	T	sA
Hermbstaedtia argenteiformis Schinz	Amaranthaceae	T	oS
Hirpicium gorterioides (Oliv.& Hiern)Rössl. ssp. *gorterioides*	Asteraceae	T	sA
Hoodia cf. *parviflora* N.E.Br.	Asclepiadaceae	T	rE
Hyphaene petersiana Klotzsch	Arecaceae	T	oS
Indigofera holubii N.E.Br.	Fabaceae	T	sA
Ipomoea adenioides Schinz	Convolvulaceae	T	oS
Isolepis hystrix (Thunb.)Nees	Cyperaceae	WA	oS

species	family	habitat	dist
Kohautia cf cynanchica DC.	Rubiaceae	T	sA
Kohautia cf *caespitosa* ssp. *brachyloba* (Sond.)D.Mantell	Rubiaceae	T	sA
Lagarosiphon ilicifolius Oberm.	Hydrocharitaceae	SA	rE
Limeum viscosum (Gay)Fenzl ssp. *viscosum* var. *macrocarpum* Friedr.	Aizoaceae	T	oS
Lindernia parviflora (Roxb.)Haines	Scrophulariaceae	WA	oS
Ludwigia octovalvis (Jacq.)Raven ssp. *brevisepala* (Brenan)Raven	Onagraceae	EA	oS
Ludwigia stolonifera (Guill.& Perr)Raven	Onagraceae	SFA	sA
Mariscus aristatus (Rottb.)Cherm. var. *atriceps* (Kück.)Podlech	Cyperaceae	WA	sA
Mariscus hamulosus (M.Bieb.)Hooper	Cyperaceae	WA	rE
Marsilea cf. unicornis Launert	Marsileaceae	EA	rE
Marsilea sp.	Marsileaceae	LFA	?
Merremia multisecta Hallier f.	Convolvulaceae	T	rE
Mollugo cerviana (L.)Ser. ex DC.	Aizoaceae	T	sA
Neptunia oleracea Lour.	Fabaceae	SFA	sA
Nymphaea nouchali Burm.f. var. *caerulea* (Sav.)Verdc.	Nymphaeaceae	LFA	sA
Nymphoides indica (L.)Kuntze ssp. *occidentalis* A.Raynal	Menyanthaceae	LFA	sA
Oryza longistaminata A.Chev.& Roehr	Poaceae	EA	sA
Oryzidium barnadii C.E.Hubb.& Schweick.	Poaceae	SFA	rE
Osteospermum sp.	Asteraceae	WA	?
Ottelia exserta (Ridley)Dandy	Hydrocharitaceae	LFA	oS
Panicum maximum Jacq.	Poaceae	T	sA
Pechuel-Loeschea leubnitziae (Kuntze)O.Hoffm.	Asteraceae	T,RU	sA
Pentzia sp.	Asteraceae	WA	?
Phragmites mauritianus Kunth.	Poaceae	EA,SFA	sA
Pogonarthria squarrosa (Roem.& Schult.)Pilg.	Poaceae	T	sA
Polygala pallida E.Mey.	Polygalaceae	T	oS
Portulaca oleracea L.	Portulacaceae	T	sA,i
Pterodiscus aurantiacus Welw.	Pedaliaceae	T	oS
Pupalia lappacea (L.)A.Juss. var. *lappacea*	Amaranthaceae	T,RU	sA, i
Pycreus macrostachyos (Lam.)J.Raynal	Cyperaceae	EA	sA
Schmidtia kalihariensis Stent	Poaceae	T	oS
Schmidtia pappophoroides Steud	Poaceae	T,RU	sA
Schoenoplectus corymbosus (Roth.ex Roem.& Schult.)J.Raynal	Cyperaceae	EA	sA
Schoenoplectus praelongatus (Poir)J.Raynal	Cyperaceae	EA	sA
Schoenoplectus muricinux (C.B.Cl.)J.Raynal	Cyperaceae	EA	sA
Schoenoplectus sp.1	Cyperaceae	EA	?
Schoenoplectus sp.2	Cyperaceae	EA	?

species	family	habitat	dist
Senna italica Mill. spp. *arachoides* (Burch.)Lock	Fabaceae	T	sA
Senna occidentalis (L.)Link	Fabaceae	T	sA,i
Sesamum triphyllum Welw. ex Aschers var. *triphyllum*	Pedaliaceae	T	sA
Sesbania microphylla Phill.& Hutch.	Fabaceae	T	rE
Sesuvium sesuvioides (Fenzl.)Verdc. var. *sesuvioides*	Aizoaceae	T	oS
Setaria verticillata (L.)Beauv.	Poaceae	T,RU	sA
Solanum nigrum L.	Solanaceae	T,RU	sA,i
Solanum rigescentoides Hutch.	Solanaceae	T	NE
Tephrosia purpurea (L.)Pers. ssp. *leptostachya* (DC.)Brummit	Fabaceae	T	oS
Terminalia prunioides Laws.	Combretaceae	T	oS
Tragus racemosus (L.)All.	Poaceae	T,RU	sA
Typha capensis (Rohrb.)N.E.Br.	Typhaceae	EA	sA
Utricularia gibba L.	Lentibulariaceae	SA	oS
Vahlia capensis (L.f.)Thunb. ssp. *vulgaris* Bridson var. *vulgaris*	Vahliaceae	T	sA