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Trial on Improving the Roosting Habitat for Wintering Waterfowl in Ponds #20 and #24 at Mai Po Nature Reserve : 2005/06

FINAL REPORT : AFCD/SQ/20/05

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[Cover photo: Northern Shoveler *Anas clypeata* (Photo by Neil Fifer)]

0. EXECUTIVE SUMMARY

i The World Wide Fund For Nature Hong Kong (WWF-HK) has since the 1990s created a series of freshwater ponds in southern Mai Po Nature Reserve and manages them using conventional techniques as specified in the 2006-2010 site management plan; vegetation management (cutting, planting, manual removal and herbicide control), occasional excavation works to remove silt and re-profile slopes, and manipulation of water levels.

ii Through this management these ponds are maintained in favourable conservation condition and consequently support flora and fauna not found elsewhere in the Nature Reserve. In particular, the ponds annually attract several thousand wintering Anatidae. In 2005 a habitat management trial was undertaken to investigate ways to improve the current management regime for the benefit of Anatidae.

iii The aims of the project are:

- To determine if regular cutting of bund and bank side vegetation can create habitat conditions to attract greater numbers of roosting Anatidae.
- To investigate the Anatidae preference of different species of aquatic vegetation for night time roosting and foraging.

iv In Ponds #20a-f and #24a-g (containing 13 sub-ponds), the 5 kilometre network of bund and bank side vegetation was cut, collected and removed on a 4-week rotation period between mid-August and early November 2005 using a combination of WWF staff and contractors. Peak numbers of roosting Anatidae had to be determined on 16 occasions in 8 of the 13 sub-ponds between October 2005 and April 2006 to assess the effectiveness of the treatment.

Vegetation Cutting

v Vegetation cutting work was completed successfully on a 4-week rotation resulting in both series of ponds being cut three times. This created a minimum sward height of 30cm between treatments and favourable conditions (<10cm) lasting longer into the winter period (approximately mid-December) than the normal WWF Hong Kong management.

vi Following completion of the treatment, the mean monthly Anatidae count increased from the previous winter period by +66.3% in Pond #20a-f and +185.5% in Pond #24f-g. For both ponds, the largest increase occurred in November. The peak count in winter 2005/06 (#20a-f and #24f-g combined) was 4,851 individuals compared to 3,378 in 2004/05.

vii In 2005/06, 90% of the total 7-month count data comprised Northern Pintail, Common Teal, Northern Shoveler and Tufted Duck. With the exception of Common Teal, all of these species increased considerably between winters. Of the 8 sub-ponds, #20a and #20c supported a substantial proportion (75.4%) of the 2005/06 total count data (77.4% in 2004/05). Sub-ponds #20e, #20f and #24f supported the least number of Anatidae (7.2% combined). Anatidae peaked in December (4,851) reconfirming the 2004/05 finding that peak numbers inside Mai Po Nature Reserve occur in December not January as is seen in Deep Bay.

Aquatic Vegetation Planting

viii Three aquatic plant species were planted into six 100m^2 quadrats located inside the centralised areas of Sub-ponds #20f and #24f (3 quadrats in each). Planting commenced in early August and finished in mid-September. An additional quadrat was located inside Sub-pond #24g to encompass another type of aquatic plant species which was growing abundantly. Eighteen observations were then made upon Anatidae usage of each planted species between late November 2005 and late April 2006.

xi Heavy rain in late September affected several of the planted species. In one instance replacement planting was necessary and in another 3 quadrats had to be reduced in size (50%) before Anatidae monitoring commenced. Thereafter, the percentage cover of all planted species varied through the winter, sometimes falling below 10%. Under such conditions observation data was omitted from the analysis.

x The Vegetation Use Study showed that of the four aquatic species, Barnyard Millet was more attractive for roosting or feeding accounting for 54.0% of the observation data. Usage is predominantly by Common Teal and Eurasian Wigeon. Results also show Rice Grass used by Eurasian Wigeon and Northern Pintail at a relatively higher rate than both Water Spinach and Knot Grass. Five of the 8 Anatidae species recorded during the survey made use of all four planted species. Knot Grass and Rice Grass attracted the highest Anatidae diversity.

Discussion/Recommendation

xi The chosen indicator of success was positively attained and it is therefore recommended to incorporate a shorter cutting rotation period into the 'normal' vegetation management programme for the freshwater ponds.

xii The large Anatidae increase between winter periods is not consistent with the Ramsar Site, which remained fairly static. Because the vegetation cutting treatment was constant between years, it is probable that the recent application of an intense 4-week cutting rotation period is positively changing bund and bank side sward composition for attracting Anatidae. This warrants further investigation.

xii Based upon the findings of this report, it is recommended to plant Barnyard Millet into the centralised areas of a few selected freshwater ponds to promote their attractiveness to Anatidae. Basic agricultural techniques and knowledge gained through this study can be applied to increase chances of success. Further study upon different plant species could provide important information for further enhancement works.

1. INTRODUCTION

1.1 Background

1.1.1 In accordance with the 2006-2010 Mai Po Marshes Wildlife Education Centre and Nature Reserve Management Plan (WWF-HK, 2006b), a series of rain-fed freshwater ponds continue to be established in the southern portions of Mai Po Nature Reserve (MPNR). The two main ponds established to date (former fishponds #20 and #24), are known to be particularly successful in providing favourable roosting habitat for wintering Anatidae. This can be partially attributed to vegetation management practices to control the height and spread of bund, interior and bankside (water's edge) emergent plants. Water level management, water quality and location are other important site factors to consider.

1.1.2 Preliminary observations upon Anatidae show bund and bankside habitats are used for daytime roosting, particularly when bund vegetation is short and the water's edge is devoid of vegetation with exposed mud and shallow water. Anecdotal observations also suggest a preference for night time roosting inside clumps of aquatic vegetation (*Paspalum* spp.), approximately 20 - 30cm tall in centralised areas of the ponds.

1.1.3 WWF Hong Kong freshwater vegetation management prescriptions include (1) bund vegetation cutting in May and September using backpack operated grasscutters and (2) a combination of hand removal and herbicide spraying (Glyphosphate) to prevent encroachment of interior and bankside vegetation. All cut or dead vegetation is then removed from the pond areas (resource dependant). Without appropriate management, rank bund vegetation would dominate leading to a gradual reduction in open water area and choking of the water body. Such conditions are undesirable for Anatidae.

1.1.4 Quantitative and first hand knowledge of freshwater vegetation management is limited in the region although similarities can be found with fishpond enhancement studies and works. Management practices at the Lok Ma Chau Ecological Compensation Area (LMCECA) set a target height of less than 10cm for 70-80% of bund vegetation (Anon, 2002b). It is noted these attributes are implemented to attract a diversity of waterbirds, not just Anatidae. A field trial on the conversion of abandoned fishponds to freshwater marsh conducted under the Study on Wetland Compensation (Anon, 2004), employed a vegetation cutting regime of three times per month in the dry season and almost continuos in the wet season in order to maintain their desired conditions (a mosaic of different vegetation heights).

1.1.5 Repeated frequent cutting of vegetation causes change to sward species composition such that more tolerant species and those that reproduce vegetatively increase in abundance. A study in Bridgewater Bay, England (IWRB, 1982), showed that repeated year-on-year cutting eliminated rank growth of grasses and resulted in a sward composition highly suitable for Eurasian Wigeon (*Anas penelope*). In general, overseas management practices for bankside or marshy vegetation involve a combination of cutting and livestock grazing - sometimes in conjunction or as a one-off short term activity (aftermath grazing) - to obtain optimal habitat conditions. The use of livestock for conservation purposes is not common practice in Hong Kong although an 18-month study upon Asian Water Buffalo (*Bubalus bubalis*) commenced by WWF Hong Kong in May 2006 (WWF-HK, 2006c) should help reduce the knowledge gap.

1.1.6 The establishment of interior freshwater pond vegetation to benefit Anatidae is similarly under-researched in the region. The LMCECA project set a target of 10-20% emergent vegetation inside several of their main ponds. This percentage cover is consistent with freshwater pond management in the United Kingdom (RSPB, 2002). In Hong Kong, Anatidae have been observed roosting inside clumps of *Paspalum* spp., but anecdotal observations include Barnyard Millet (*Echinochloa crus-galli*), Water Spinach (*Ipomoea reptans*) and Rice Grass (*Leersia hexandra*). Sometimes these species are taken as fodder (Dr. Lewellyn Young *pers comm*).

1.1.7 In respect of management regimes employed by organisations other than WWF Hong Kong to manage bund and bankside vegetation, a more frequent cutting regime could potentially create better conditions for waterbirds, in particular Anatidae. The main problem with the current regime is that substantial vegetation growth occurs after the final September cut and by the time wintering Anatidae arrive in late October some habitat areas are unfavourable.

1.1.8 In 2004, a similar vegetation cutting trial was undertaken at MPNR (Anon, 2005b). Although that trial recorded a large increase in Anatidae, it was tentatively deemed successful because of the limited validity of the comparative Anatidae data set from the previous winter period. However, for this study the 2004/05 winter data set forms a reliable baseline for comparison purposes.

1.2 Aims

1.2.1 The aims of the project are:

- To determine if regular cutting of bund and bankside vegetation can create habitat conditions to attract greater numbers of roosting Anatidae.
- To investigate the Anatidae preference of different species of aquatic vegetation for night time roosting and foraging.

1.3 Approach

1.3.1 The project involved three distinct work phases:

- *Phase I*. A 2 2/3-month period of continuous habitat enhancement works:
  (1) Cutting of bund (internal and boundary) and bankside vegetation in Ponds #20 and #24 on a 4-week rotation cutting regime.
  (2) Vegetation planting to create islands of four different species of emergent aquatic vegetation in centralised areas of Sub-ponds #20f, #24f and #24g.

- *Phase II*. Ornithological monitoring activities throughout the winter months to assess the efficacy of the enhancement works:
  (1) Counts of roosting Anatidae in Ponds #20a-f and #24f-g
  (2) Anatidae vegetation use observations in Sub-ponds #20f, #24f and #24g

- *Phase III*. Production of project reports - Waterfowl Report (Anon, 2006b) and Final Report.

1.3.2 *Phase I* work was carried out in late summer and autumn 2005 because MPNR is a sensitive wildlife area and subsequently all major work operations are restricted to particular seasons or months. Wintering Anatidae arrive in Hong Kong from late October and remain until early April the following year. This is immediately followed by the spring migration period, which normally finishes in early June. Therefore enhancement works were undertaken between August and very early November to minimise disturbance to migratory waterbirds.

2. METHODS

2.1 Study Area

2.1.1 The project area includes all 13 sub-ponds located within Ponds #20 and #24 (Figure 1). Being located away from the main visitor trails, and therefore less affected by disturbance, the ponds provide ideal research conditions.

2.2 Vegetation Management

Vegetation cutting

2.2.1 Contractors and WWF Hong Kong staff worked for a 2 2/3-month period cutting and clearing (raking) vegetation (Appendix I). Workers operated on a 4-week rotational basis between the two series of Ponds at #20 and #24 from mid-August until early November 2006 consuming a total of 425 man-days.

2.2.2 The total length of bund and bankside habitat, both internal and boundary, associated with Ponds #20 and #24 is 4990m (Figure 2). The typical bund width is 10m, therefore the total area cut each time is estimated at 4.99 hectares.

2.2.3 In areas of dense vegetation, workers raked cuttings into piles at designated locations, leaving them for a 2-3 week period to reduce in weight. Once a sufficiently large volume of cut grasses had accumulated, the material was transported to the Education Centre access track alongside *gei wai* #14. In July 2006, a hired subcontractor removed all collected material from MPNR to a registered landfill site.

Figure 1. Location of Freshwater Ponds in Southern Mai Po Nature Reserve.

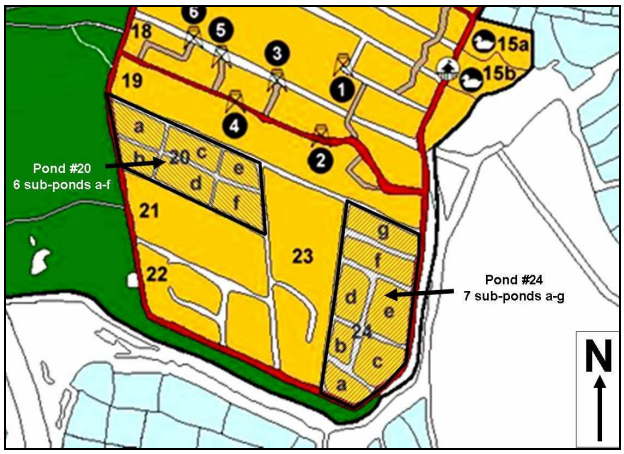
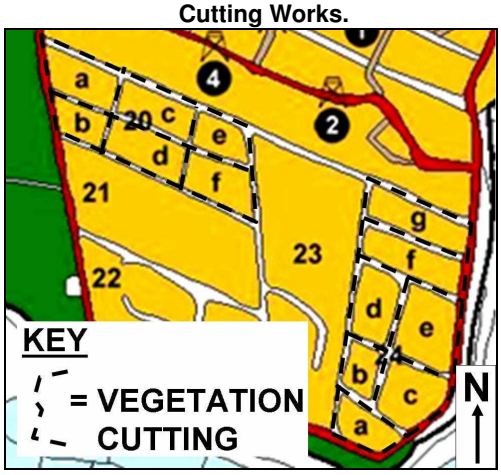


Figure 2. Location of Vegetation Cutting Works.

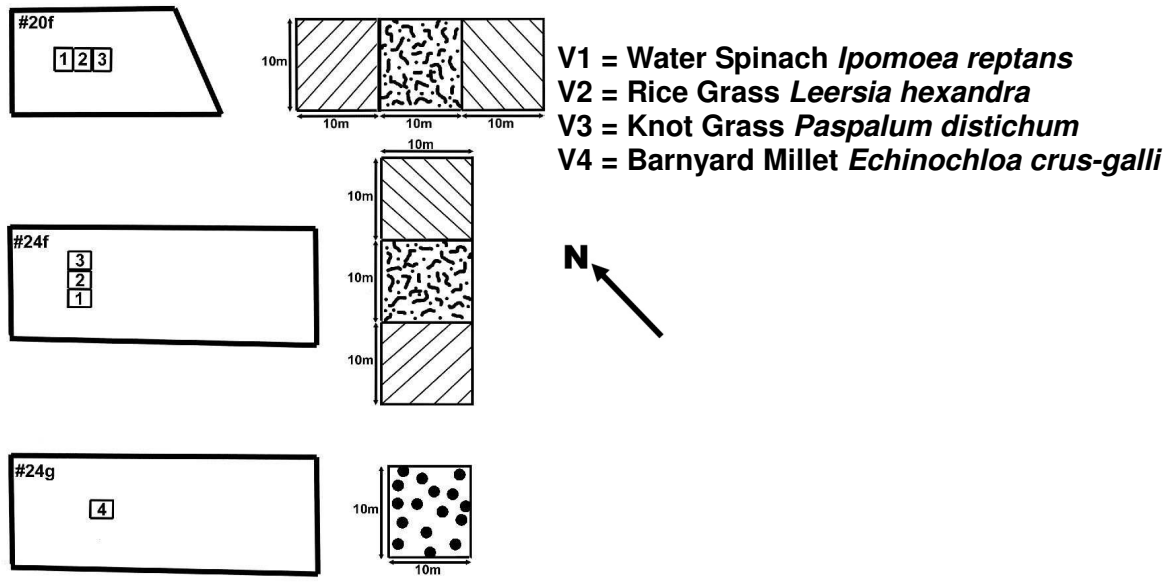


Aquatic Vegetation Planting

2.2.4 Sub-ponds #20f and #24f were both partially drained in early August 2005 to allow workers access into the interior of each pond and then three 10m x 10m quadrats marked out in each with bamboo markers (Figure 3). In Sub-pond #24f, the quadrat location was placed at a suitable distance from the reserve boundary path, to limit disturbance. Also the orientation of each "block" of 3 quadrats was designed to be parallel to the reserve boundary path to facilitate Anatidae observations (Figures 3 and 4). In Sub-pond #20f, quadrats were centrally located and similarly aligned to be perpendicular to the observation location.

2.2.5 Three plant species anecdotally known to be used by Anatidae for night time roosting and forage; Water Spinach, Rice Grass and Knot Grass, were planted into the 6 quadrats inside Sub-ponds #20f and #24f (Figure 3 & Appendix II). All vegetation was hand planted by manoeuvring small manageable sized clumps into each quadrat and inserting their roots into the saturated soil. Planting commenced in early August and continued until mid September 2005. Plant sources included various locations within MPNR, LMCECA (donated), and local markets (Yuen Long).

Figure 3. Location and Design of the Aquatic Vegetation Planting Works.



2.2.6 Following completion of the planting activities, water levels had to be altered inside both Sub-ponds through a combination of pumping water from neighbouring ponds and an accumulation of rainwater. A water level which submerged basal vegetation parts in shallow (1-2 cm) water was set.

2.2.7 By mid-September, good-sized stands of Barnyard Millet had established in Sub-ponds #24f and #24g from the former trial in winter 2004/05 (Anon, 2005b). This presented suitable conditions to study the plant species and therefore one 10m x 10m quadrat was marked out in Sub-pond #24g at a suitable distance from the perimeter path (Figures 3 and 4) for study purposes.

2.2.8 In late November (at the commencement of Anatidae monitoring) the Barnyard Millet quadrat in Sub-pond #24g had to be relocated to Sub-pond #24f because of flooding problems (section 3.1.4). Volunteer groups then began clearance of all grasses (including Barnyard Millet) from the centralised areas of Sub-pond #24f to facilitate better data quality. No grasses other than those planted for this study were present inside Sub-pond #20f at the start of Anatidae monitoring, hence no clearance works were necessary in that pond.

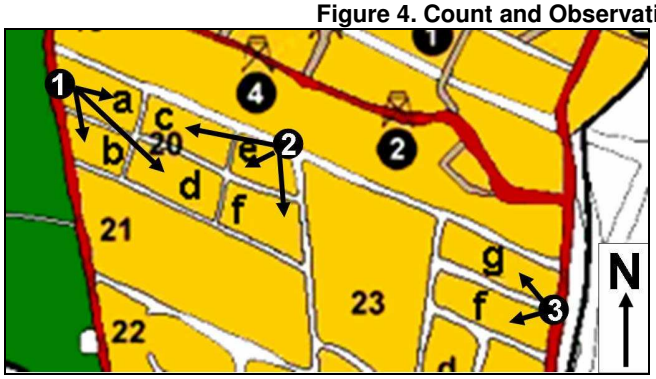
2.3 Anatidae Monitoring

2.3.1 Separate monitoring elements were devised to assess the individual effectiveness or indicate the success/failure of the works; a count of wintering Anatidae from Ponds #20a-f and #24f-g for the vegetation cutting trial, and observations of Anatidae use of the different vegetation types in Sub-ponds #20f, #24f and #24g employed for the aquatic vegetation planting trial. Reference to Anon, 2006b should be made for a comprehensive account of both monitoring activities and full data sets.

Anatidae Counts

2.3.2 Between mid October 2005 and late April 2006, sixteen bi-weekly counts were made upon Anatidae (Table 1) in 8 Sub-ponds (Pond #20a-f and #24f-g) from designated locations (Figure 4). Count dates coincided with hide tides and chosen to be within 1-2 days of the Hong Kong Bird-watching Society Monthly Ramsar Site Waterbird count to facilitate better data interpretation (as recommended in Anon, 2005a). During January and February, two extra counts were completed to coincide with the expected peak influx of Anatidae.

Figure 4. Count and Observation Locations.



❶ = Upper floor of *gei wai* hut 20a (Sub-ponds #20a, #20b and #20d)

❷ = Upper floor of scaffolding canvas hide (Sub-ponds #20c, #20e and #20f)

❸ = Perimeter path (Sub-ponds #24f and #24g)

Table 1. Anatidae Count Dates, Times and Associated Tidal Conditions : Winter 2005/06

Date	Sunset[1] (Time)	Observation Period	Tide[1] Preceding Condition	Tide[1] Height[2]	Tide[1] Condition[3]
17 October 2005[4]	17:56	17:11 – 18:11	0.6m@16:53	0.8m	↑
31 October 2005	17:47	17:02 – 18:02	0.8m@15:57	1.3m	↑
14 November 2005[4]	17:40	16:55 – 17:55	0.8m@15:32	1.7m	↑
30 November 2005	17:38	16:53 – 17:53	1.1m@15:26	1.8m	↑
19 December 2005[4]	17:43	16:58 – 17:58	1.3m@17:24	1.7m	↑
29 December 2005	17:49	17:04 – 18:04	1.2m@14:34	1.8m	↑
09 January 2006	17:56	17:11 – 18:11	1.0m@11:51	2.1m	↑
15 January 2006	18:00	17:15 – 18:15	1.1m@16:03	1.2m	↑
23 January 2006[4]	18:06	17:21 – 18:21	2.0m@16:14	1.8m	↓
07 February 2006	18:15	17:30 – 18:30	2.1m@17:10	2.0m	↓
20 February 2006[4]	18:23	17:38 – 18:38	2.1m@14:05	1.4m	↓
27 February 2006	18:26	17:41 – 18:41	0.9m@16:21	1.5m	↑
09 March 2006	18:30	17:45 – 18:45	0.5m@01:56	2.1m	↔
22 March 2006[4]	18:35	17:50 – 18:50	2.4m@13:57	1.4m	↓
18 April 2006[4]	18:44	17:59 – 18:59	2.7m@12:07	0.8m	↓
25 April 2006	18:47	18:02 – 19:02	0.7m@15:18	1.4m	↑

1 – Data from the HK Observatory (tide data relates to Tsim Bei Tsui tidal station)
2 – At mid-point of observation period
3 – General tidal condition during observation period (↑ = Rising, ↓ = Falling, ↔ = coincides with max or min tide)
4 – Dates selected to be within 1-2 days of the HKBWS Monthly Ramsar Site Waterbird Count.

Anatidae Vegetation Use Observations

2.3.3 Between late November 2005 and late April 2006, 18 observations were made upon waterbird usage of the 4 different plant species from designated locations (Figure 4). Each observation period consisted of ten 6-minute interval counts. Vegetation percentage cover in the quadrats dictated observation dates (refer to section 4.3.4).

Table 2. Anatidae Vegetation Use Study Observation Dates and Times.

Date	Sunset[1] (Time)	Observation Period
23 November 2005	17:39	16:54 – 17:54
29 November 2005	17:38	16:53 – 17:53
06 December 2005	17:39	16:54 – 17:54
08 December 2005	17:40	16:55 – 17:55
12 December 2005	17:41	16:56 – 17:56
15 December 2005	17:42	16:57 – 17:57
20 December 2005	17:44	16:59 – 17:59
30 December 2005	17:49	17:04 – 18:04
06 March 2006	18:29	17:44 – 18:44

Date	Sunset[1] (Time)	Observation Period
08 March 2006	18:30	17:45 – 18:45
09 March 2006	18:30	17:45 – 18:45
10 March 2006	18:31	17:46 – 18:46
13 March 2006	18:32	17:47 – 18:47
14 March 2006	18:32	17:47 – 18:47
16 March 2006	18:33	17:48 – 18:48
17 March 2006	18:33	17:48 – 18:48
18 April 2006	18:44	17:59 – 18:59
25 April 2006	18:47	18:03 – 19:03

[1] - Data from the HK Observatory

2.4 Indicator of Success

2.4.1 An indicator of success was chosen to assess the effectiveness of the vegetation cutting works; the 'maintenance of the number of wintering Anatidae using Pond #20a-f'. Therefore if the cutting works, being of a trial/experimental nature, result in a decline of the usual Anatidae numbers, the works are deemed unsuccessful. Conversely, an increase is considered successful. The 'usual' number is defined as the percentage of the Inner Deep Bay Ramsar Site Anatidae counted from Pond #20a-f in winter 2004/05 (due to a lack of reliable roosting data for any other winter period, winter 2004/05 is the only baseline available for comparison). An indicator of success was not deemed appropriate for the aquatic vegetation planting trial, because a comparative data set is not available.

3. RESULTS

3.1 Vegetation Management Works

Vegetation Cutting

3.1.1 The rotational cutting regime resulted in vegetation being cut three times at each pond during the 2$_{2/3}$-month work period. Cutting activities concluded in Pond #24 in early November. Vegetation was observed to be approximately 30cm in height prior to the next cut.

3.1.2 Following completion of the works in November, vegetation generally remained suitable (i.e. below 10cm) for 4-5 weeks, especially in areas heavily used by Anatidae. This was particularly noticeable on both the bund and bankside areas surrounding Sub-pond #20c. Thereafter, bund vegetation height exceeded the desired height limit (10cm) and became unfavourable (early December). Bankside vegetation remained favourable for longer periods (up to 8 weeks) and in some sub-ponds (i.e. #24f and #24g) remained favourable throughout the winter period.

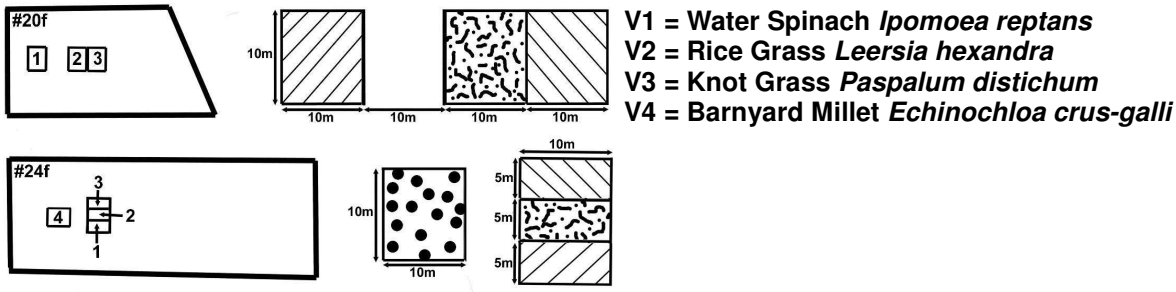
Aquatic Vegetation Planting

3.1.3 All three species were successfully planted inside the six 100m^2 quadrats by mid September and the correct water level set in each pond. However, heavy rain in late September resulted in a 60% loss of Water Spinach in Sub-pond #20f which had to be replanted. Therefore water levels had to be lowered again for 7 days and the sub-pond did not regain full operation until the very end of September.

3.1.4 By late October, several changes proved necessary to the project design before Anatidae counting commenced (Figure 5):

- Water Spinach in Sub-pond #20f established far better outside the quadrat area and therefore the quadrat was relocated accordingly.
- In Sub-pond #24f, the percentage cover of all 3 planted types had reduced in size by approximately 50%. Therefore each quadrat was resized as appropriate.
- Barnyard Millet in Sub-pond #24g began to die back in mid November. Hence the quadrat was moved to a healthy 10m x 10m stand in Sub-pond #24f.

Figure 5. Final Location and Design of Aquatic Vegetation Quadrats.



3.2 Anatidae Monitoring : 2005/06

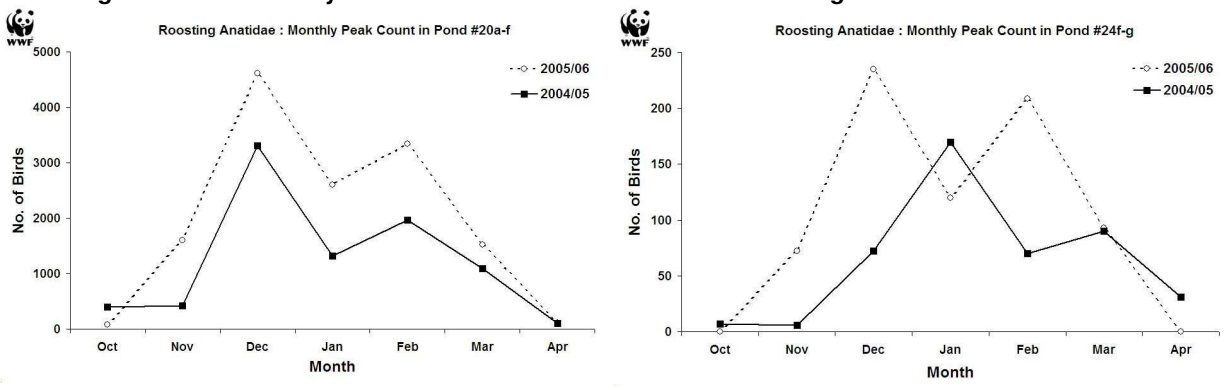
Anatidae Count

3.2.1 Over the winter period the highest peak monthly counts (Ponds #20a-f and #24f-g combined) occurred in December (4,851) and February (3,545) (Table 3). Peak counts greater than 1000 birds occurred in each of the 5 months between November and March. In the remaining months, October and April, peak counts remained low at about 100 birds (Table 3 & Figure 6).

Table 3. Peak Monthly Anatidae Counts : Winter 2005/06.

Date	Sub-Pond						Total	Sub-Pond		Total	TOTAL
	20a	20b	20c	20d	20e	20f		24f	24g		
Oct-05	3	11	48	20	0	2	84	0	0	0	**84**
Nov-05	130	11	1055	123	134	151	1604	65	7	72	**1676**
Dec-05	533	507	3320	105	27	124	4616	99	136	235	**4851**
Jan-06	228	245	1840	182	49	59	2603	29	91	120	**2723**
Feb-06	737	428	1907	198	47	19	3336	100	109	209	**3545**
Mar-06	723	235	385	134	18	27	1522	92	1	93	**1615**
Apr-06	0	0	109	2	0	3	114	0	0	0	**114**
Mean	**336.3**	**205.3**	**1237.7**	**109.1**	**39.3**	**55.0**	**1982.7**	**55.0**	**49.1**	**104.1**	**2086.9**
S.D	**323.3**	**208.5**	**1197.0**	**74.7**	**46.2**	**60.0**	**1663.5**	**45.0**	**60.3**	**92.4**	**1754.3**
Rank	2	3	1	4	8	5		5	7		

Figure 6. Peak Monthly Anatidae Counts in Ponds #20a-f and #24f-g : Winter 2004/05 to 2005/06.



3.2.2 Sub-pond #20c recorded the highest individual Anatidae count (3,320 on 29 December), highest mean peak monthly count (1,237.7) and accounted for 58.8% of all Anatidae records during the winter period. Sub-pond #20a recorded a mean peak monthly count of 336.3 individuals, accounting for 16.8% of the winter Anatidae data set. Collectively, Sub-ponds #20a and #20c comprise 75.4% of all Anatidae data.

3.2.3 A total of 13 Anatidae species were recorded. Three are considered to be of 'uncertain' origin; Falcated Duck, Greater Scaup and Mallard/Spot-bill hybrid (all recorded in April 2006), and are therefore omitted from the data set (refer Anon, 2006b). Northern Pintail, with a mean peak monthly count of 651.5 individuals and high counts of 2,068 on 07 February (Table 4) and 2,056 on 29 December was the most abundant species. Common Teal (mean = 236.6), Northern Shoveler (mean = 189.6) and Tufted Duck (mean = 184.4) are notably more abundant than the other species and, collectively with Northern Pintail, comprise 89.6% of the Anatidae count totals.

Table 4. Maximum Anatidae Species Counts : Winter 2005/06.

	Individual Sub-pond			Ponds #20a-f and #24f-g			
Species	Maximum Count	Sub-pond	Date(s)	Maximum Count	Date(s)	Mean[1] Count	Rank[2]
Northern Pintail	1600	#20c	07-Feb-06	2068	07-Feb-06	651.5	1
Common Teal	496	#20a	22-Mar-06	628	09-Mar-06	236.6	2
Northern Shoveler	1150	#20c	29-Dec-05	1471	29-Dec-05	189.6	3
Tufted Duck	540	#20c	09-Jan-06	633	09-Jan-06	184.4	4
Eurasian Wigeon	103	#20c	22-Mar-06	228	29-Dec-05	94.1	5
Garganey	126	#20a	22-Mar-06	253	22-Mar-06	41.9	6
Gadwall	28	#20f	15-Jan-06	31	15-Jan-06	9.2	7
Ferruginous Duck	3	#20a	07-Feb-06 09-Mar-06	3	15-Jan-06 07-Feb-06 09-Mar-06	0.8	8
Spot-billed Duck	3	#24f	15-Jan-06	3	15-Jan-06	0.6	9
Common Pochard	3	#20e	30-Nov-05	3	30-Nov-05	0.3	10

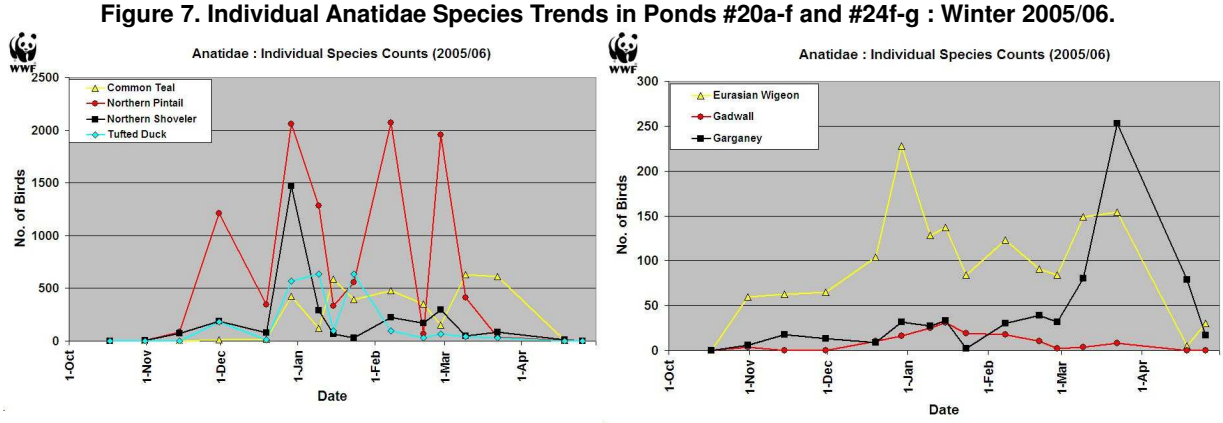
[1] - Calculated from all 16 counts (Oct-Apr)
[2] - Rank based on mean count

3.2.4 Counts of 31 Gadwall and 253 Garganey (Table 4) are both among the highest for those species in Hong Kong in recent years (Anon, 2006b). In addition, the four individualcounts of 3 Ferruginous Duck, being of a 'near threatened' conservation status (Birdlife International, 2000), are important.

3.2.5 Notable count trend patterns (Figure 7) include:

- Erratic fluctuations in the number of roosting Northern Pintail.
- Comparative late usage of the ponds by Common Teal and peak count in late winter (March).
- Near confined usage of the ponds by Tufted Duck to the period between late December and early February.
- Clearly defined peak usage of the ponds by Garganey in late March.
- Suggestive peak usage of the ponds by Eurasian Wigeon in late December and again in mid March. Also a sustained and steady use of the ponds throughout winter.

Figure 7. Individual Anatidae Species Trends in Ponds #20a-f and #24f-g : Winter 2005/06.



3.2.6 A comparison between the Ramsar Site Anatidae and Pond #20 Anatidae count data sets (Table 5), show that for the more abundant months (November to March) 51.3% of the Ramsar Anatidae utilised the Pond for roosting in January 2006 and 40.3% in March 2006.

Table 5. Comparison of Anatidae Count Data between Pond #20a-f and the Ramsar Site : Winter 2005/06.

Pond #20a-f		Ramsar Site*		
WWF HK Count Date	**Total no. of Anatidae**	**HKBWS Count Date**	**Total no. of Anatidae**	**Pond #20/Ramsar (%)**
17-Oct-05	0	16-Oct-05	35	0.0%
14-Nov-05	218	13-Nov-05	7355	3.0%
19-Dec-05	428	18-Dec-05	6150	7.0%
23-Jan-06	1662	22-Jan-06	3241	51.3%
19-Feb-06	742	19-Feb-06	9571	7.8%
22-Mar-06	1176	19-Mar-06	2921	40.3%
18-Apr-06	112	16-Apr-06	113	~100.0%

* - HKBWS data (Anon, 2006a)

Anatidae Vegetation Use

3.2.7 Throughout the winter period, vegetation cover in each of the survey quadrats varied (refer to section 4.3.4). To improve the data interpretation and analysis, all usage data recorded from a quadrat where the vegetation percentage cover fell below 10% is considered unreliable and omitted (refer to section 4.4.2). Subsequently 27.8% of the Water Spinach data set, 33.3% of Rice Grass, and 100% for both Knot Grass and Barnyard Millet are used in the analysis. In addition, the Barnyard Millet quadrat in Sub-pond #24g had to be relocated to Sub-pond #24f after the first observation date, but this did not affect the study data because on the first observation date, no Anatidae were recorded using the Barnyard Millet quadrat.

3.2.8 For the combined data set (Sub-ponds #20f, #24f and #24g), Barnyard Millet, with a mean observation rate of 10.85 birds, proved to be considerably more attractive to Anatidae than the other 3 vegetation types (Table 6), accounting for 54.0% of the entire data set. Usage is predominantly by Common Teal and Eurasian Wigeon (Figure 8). Ranked second with a mean observation rate of 4.35, Rice Grass is largely used by Eurasian Wigeon and Northern Pintail.

3.2.9 Of the 8 Anatidae species recorded, Eurasian Wigeon, Common Teal and Northern Pintail were recorded more frequently, accounting for 83.3% of all observations. Five of the 8 species made use of all 4 different vegetation types during the winter period. Knot Grass and Rice Grass attracted the highest diversity of species (8 and 7 respectively).

Figure 8. Anatidae Vegetation Usage : Winter 2005/06.

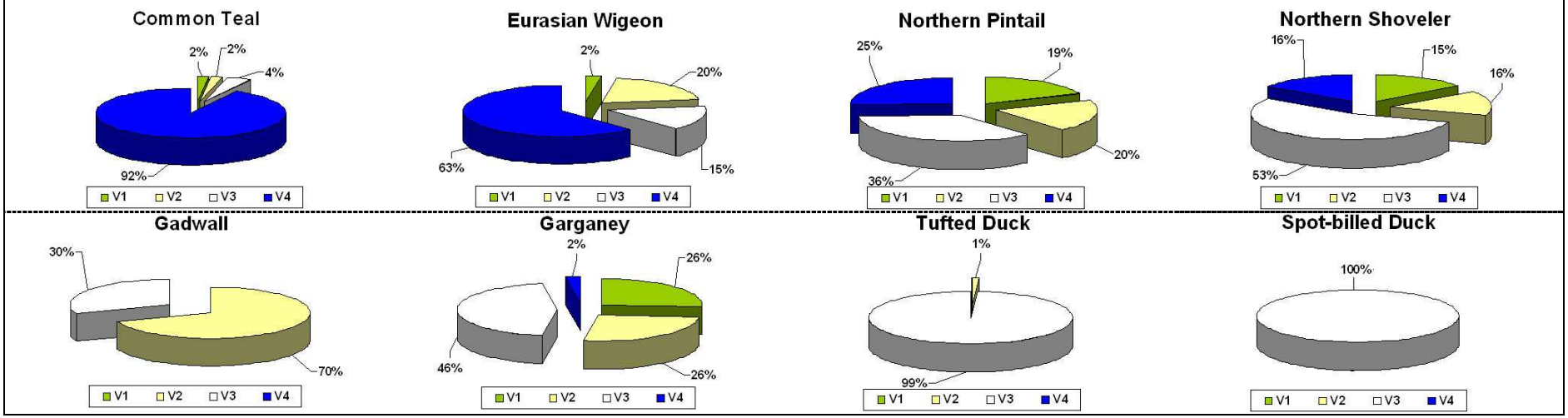


Table 6. Summary of the Vegetation Use in Each Quadrat for Individual Anatidae Species in Sub-ponds #20f and #24f.

	Observations per Species								
	Number					Mean			
Species	**V1**	**V2**	**V3**	**V4**	**Total**	**V1**	**V2**	**V3**	**V4**
Common Teal	11(*87*)*	72(*144*)*	23	532	**578**	0.18	0.17	0.11	4.93
Eurasian Wigeon	20(*59*)*	158(*253*)*	124	499	**801**	0.33	2.19	0.57	4.62
Gadwall	0(*34*)*	16(*12*)*	7	0	**23**	0.00	0.22	0.03	0.00
Garganey	11(*23*)*	11(*38*)*	19	1	**42**	0.18	0.15	0.09	0.01
Northern Pintail	81(*12*)*	84(*91*)*	154	109	**428**	1.35	1.17	0.71	1.01
Northern Shoveler	30(*71*)*	31(*4*)*	107	31	**199**	0.50	0.43	0.50	0.29
Spot-billed Duck	0	0(*1*)*	14	0	**14**	0.00	0.00	0.06	0.00
Tufted Duck	0(*1*)*	1	83	0	**84**	0.00	0.01	0.38	0.00
TOTAL	**153**	**313**	**531**	**1172**	**2169**	**2.55**	**4.35**	**2.26**	**10.85**
					RANK	**3**	**2**	**4**	**1**

Code	Vegetation Species
V1	***Ipomoea reptans*** **(Water Spinach)**
V2	***Leersia hexandra*** **(Rice Grass)**
V3	***Paspalum distichum*** **(Knot Grass)**
V4	***Echinochloa crus-galli*** **(Barnyard Millet)**

No. of Observation Intervals per Species				
V1	**V2**	**V3**	**V4**	**Total**
60(*156*)*	72(*144*)*	216	108	456

* - Numbers in parentheses refer to the number of omitted observations (refer to section 3.2.7).

4. DISCUSSION

4.1 Anatidae Comparison

4.1.1 Anatidae increased in Pond #20a-f from the corresponding 2004/05 winter period by a mean monthly change of +66.3% (Table 7). Percentage increases were observed in 6 of the 7 winter months, being highest in November (+286.5%). A similar mean monthly increase occurred in Pond #24f-g (+185.6%) with the highest change in November (+1100%) and increases observed in 4 of the 7 survey months.

Table 7. Comparison of the Anatidae Peak Count Data for Ponds #20a-f and #24f-g : Winters 2004/05 & 2005/06.

	Pond #20a-f			Pond #24f-g		
	2004/05*	2005/06	% Change	2004/05*	2005/06	% Change
Oct	394	84	-78.7%	7	0	-100.0%
Nov	415	1604	+286.5%	6	72	+1100.0%
Dec	3306	4616	+39.6%	72	235	+226.4%
Jan	1321	2603	+97.0%	170	120	-29.4%
Feb	1961	3336	+70.1%	70	209	+198.6%
Mar	1086	1522	+40.1%	90	93	+3.3%
Apr	104	114	+9.6%	31	0	-100.0%

* - Data from Anon 2005a

4.1.2 Of the more abundant Anatidae species recorded from both winter periods (based on mean count), 4 species increased and 2 decreased between the two periods (Table 8). Of those to increase, Northern Shoveler and Tufted Duck both showed significant changes (>600%). Others of note include Garganey and Northern Pintail. Eurasian Wigeon, the 2nd most common Anatidae inside MPNR in winter 2004/05, declined significantly by 68.4%. Common Teal declined by 23.0%.

Table 8. Comparison of the Most Abundant Anatidae Species : Winters 2004/05 & 2005/06.

	2004/05		2005/06		
Species	Maximum Count	Mean Count[1]	Maximum Count	Mean Count[2]	% Change[3]
Common Teal	1549	307.4	628	236.6	-23.0
Eurasian Wigeon	1332	298.0	228	94.1	-68.4
Garganey	87	27.0	253	41.9	+55.2
Northern Pintail	1714	273.3	2068	651.5	+138.4
Northern Shoveler	135	24.6	1471	189.6	+670.7
Tufted Duck	138	25.1	633	184.4	+634.7

[1] - Calculated from 15 counts (Oct-Apr)
[2] - Calculated from 16 counts (Oct-Apr)
[3] - Based on mean count (only species with a mean count >10.0 are shown)

4.1.3 Anatidae numbers increased inside the surveyed ponds in 2005/06 from the previous winter despite lower total numbers being recorded from the Ramsar Site in 2005/06 (refer to section 4.6.1). This suggests that the cutting regime created more suitable conditions in 2005/06, but because the treatment remained constant between years, there may be a cumulative impact upon the vegetation caused by the increased frequency of cutting over the two-year period. Although unknown, sward composition and growth vigour may be affected.

4.2 Effectiveness of Vegetation Cutting

4.2.1 Cutting bund vegetation on a 4-week rotation (i.e. shorter time interval than normal WWF Hong Kong management) had a similar effect upon sward height in 2005 to the previous field trial in 2004 whereby vegetation generally attained a height 30cm above the ground between each cut. After the final treatment (late October in Pond #20 and early November in Pond #24) vegetation remained favourable (i.e. <10cm) for approximately 5-6 weeks, although much longer in areas heavily used by Anatidae.

4.2.2 The main benefits to Anatidae are brought about by the length of time conditions remain favourable beyond the final treatment date and because Anatidae arrive in late October, the attainment of favourable conditions throughout the entire summer period may not be justified. However, it is noted that (1) benefits to other bird species might arise from achieving these favourable conditions in autumn (i.e. Pipits, Wagtails, Snipe, etc.) (2) changes to sward species composition, which is not monitored, may benefit Anatidae [similar to the Bridgewater Bay findings (IWRB, 2002)] and (3) repeated cutting can reduce vegetation growth vigour in the long-term and, in theory prolong the desired effects.

4.2.3 To retain vegetation height below 10cm (favourable conditions) throughout the summer period, it is estimated that a 1 to 2-week cutting interval is required. This is consistent with results from the Wetland Compensation Study field trials on the conversion of abandoned fishponds to freshwater marsh (Anon, 2004).

4.3 Effectiveness of Aquatic Vegetation Planting

4.3.1 Planting works in both sub-ponds proved to be a relatively labour intensive exercise. In total 34 man-days were required to collect plants, mark out quadrat areas, pump water, and plant vegetation.

4.3.2 Water Spinach was the most problematic species to establish and highly susceptible to water level fluctuations (similar to the 2004 trial). Even after the replacement planting in Sub-pond #20f, Water Spinach did not establish in the desired location and consequently the survey quadrat had to be relocated. The failure of 50% of each planted species in Sub-pond #24f, resulted from high rainfall in late September which caused the peripheral quadrat vegetation of Water Spinach and Knot Grass to die. Also because of the higher water level, both species favoured growth towards the shallower central areas and out-competed Rice Grass.

4.3.3 Barnyard Millet established exceptionally well in Sub-ponds #24f and #24g and colonised many central shallow areas in the 12-month period since being planted for the previous trial in 2004. The original survey quadrat used in 2005 (#24g) succumbed to water level fluctuations and consequently a new healthier area was reselected in #24f.

4.3.4 As the winter period progressed, the percentage cover of all species varied (Table 9). This was caused by, or from the combination of, (1) Anatidae grazing (2) post planting success/failure of the vegetation to establish and (3) natural die back as winter sets in. In early March, the percentage cover of several species recovered as warmer temperatures returned.

4.4 Effectiveness of Anatidae Monitoring

4.4.1 The sixteen Anatidae counts produced a data set adequate for assessing the vegetation cutting works and indicator of success. The concentration of counts in January and February reconfirmed the finding in 2004/05 that January is not the peak month for Anatidae inside MPNR. To complete each co-ordinated count, 3 staff conducted counts at different locations over the winter period (Total = 8.8 man-days).

4.4.2 Eighteen observations proved to be sufficient to meet the Vegetation Use Study requirements and resulted in the collection of a reasonable sized data set. However because the percentage cover of some vegetation inside the quadrats decreased to a level where the quality of data was possibly compromised (<10%) i.e. bird usage of a quadrat could not be confidently assumed to be associated with the vegetation, 72.2% of the data set for Water Spinach and 66.7% for Rice Grass had to be omitted from the analysis. Each observation date required 2 recorders at different locations (Total = 9.6 man-days).

Table 9. Approximate Percentage Cover of Planted Vegetation : Winter 2005/06

	Sub-pond #20f			Sub-pond #24f			
Date	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V4**
23-Nov-05	70	65	75	70	75	75	100
29-Nov-05	65	65	60	50	45	75	100
06-Dec-05	45	65	45	10	10	70	100
08-Dec-05	40	65	35	10	10	70	100
12-Dec-05	25	60	30	**5**	**5**	70	100
15-Dec-05	10	60	25	**0**	**0**	65	100
20-Dec-05	**5**	50	25	**0**	**0**	50	100
30-Dec-05	**0**	40	25	**0**	**0**	50	100
06-Mar-06	**0**	**0**	30	**0**	**0**	15	75
08-Mar-06	**0**	**0**	30	**0**	**0**	10	75
09-Mar-06	**0**	**0**	30	**0**	**0**	10	75
10-Mar-06	**0**	**0**	35	**0**	**0**	10	75
13-Mar-06	**0**	**0**	35	**0**	**0**	10	75
14-Mar-06	**0**	**0**	35	**0**	**0**	10	75
16-Mar-06	**0**	**0**	40	**0**	**0**	10	75
17-Mar-06	**0**	**0**	40	**0**	**0**	10	75
18-Apr-06	**0**	**5**	45	**0**	**0**	60	80
25-Apr-06	**0**	**5**	45	**0**	**0**	80	80

Bold = % cover <10%

Code	Vegetation Species
V1	***Ipomoea reptans*** **(Water Spinach)**
V2	***Leersia hexandra*** **(Rice Grass)**
V3	***Paspalum distichum*** **(Knot Grass)**
V4	***Echinochloa crus-galli*** **(Barnyard Millet)**

4.4.3 The omission of data from the study at a particular period in the winter cycle (i.e. December-February), created bias towards certain Anatidae species. For example Tufted Duck primarily occur inside MPNR between December and February (Figure 7 – consistent with the HK migration pattern Carey, *et al.* 2001) and therefore has a reduced probability of being recorded in comparison to other species.

4.4.4 The clearance of non-planted centralised vegetation from Sub-pond #24f at the commencement of Anatidae monitoring served to increase the overall data quality. This reduced the likelihood of Anatidae being attracted into the pond by the presence of other grass species or a larger quantity of Barnyard Millet.

4.5 Timetabling and Resources

4.5.1 Despite aquatic vegetation establishment problems, *Phase I* and *Phase II* were completed on schedule. *Phase III* was completed several months after that specified in the agreed contract. An additional 54.3 man-days were required to complete the project (2.0 – cut grasses, 34.0 – supervise and oversee the aquatic vegetation planting, 9.3 – Anatidae monitoring and 9.0 - report production). The original project costing for vegetation cutting activities proved accurate. Replacement metal blades and safety equipment were the only non-funded additional capital expenses incurred by WWF Hong Kong. Other costs included transport and plant (vegetation) purchase costs. This extra staff time and expenses are donated to the project.

4.6 Indicator of Success

4.6.1 The 'usual' number of Anatidae in 2005/06 increased in Pond #20 from the previous winter (Table 10). This included increases in all 3 months between December to February (the most abundant months in Deep Bay), the highest being January. Therefore the indicator is deemed to have been successfully achieved.

Table 10. Comparison of Anatidae Numbers Between the Ramsar Site and Pond #20.

RAMSAR SITE[1]			
Winter	**Dec**	**Jan**	**Feb**
2004/05	9,455	8,278	7,639
2005/06	6,150	3,241	9,571

[1] – HKBWS data (Anon, 2005c & Anon, 2006a)

Pond #20[2]		
Dec	**Jan**	**Feb**
3,306	1,321	1,961
4,616	2,603	3,336

[2] – Peak monthly count (Table 3 and Anon, 2005a)

Pond #20/RAMSAR (%)		
Dec	**Jan**	**Feb**
35.0	16.0	25.7
75.1	80.3	34.9

5. RECOMMENDATIONS

5.1 Habitat Management

5.1.1 Consideration should be given to incorporation of the shorter 4-week rotation vegetation cutting regime into the normal WWF Hong Kong freshwater pond management programme. To do so would require either the employment of seasonal staff or contractors. Alternatively, consideration should be given to the purchase of a two-wheel walking tractor. Fitted with a double reciprocating bar for light/medium scrub, it is capable of cutting vegetation on uneven ground (including bank slopes) and a proportion of the bankside vegetation exceptionally quickly (estimated to be 8 times faster than a backpack operated brushcutter). A typical 11 hp fully equipped tractor (Honda BCS) would cost HK$35,000 (including shipment costs to Hong Kong). The tractor could also be used to cut large areas of Reed Grass (*Phragmites australis*) inside MPNR.

5.1.2 Without the input of further resources and in consideration of current staffing and financial resources, the following cutting regime is suggested as a substitute to that used during normal management practices:

- **November – April**: No cutting
- **May – August**: Single cut during the May/June period and another in the July/August period
- **September – October**: Single cut per month with the last cut at the end of October/beginning of November.

5.1.3 Mai Po Nature Reserve is an important Odonata site in Hong Kong (WWF-HK, 2005a) especially the freshwater Ponds #20 and #24 which support a high species diversity. Therefore vegetation management should consider Odonata requirements by retaining areas of emergent bankside vegetation (i.e. rushes and sedges) in summer and autumn months. It is suggested that one third of the vegetation along each pond edge be left uncut and then rotated every month. This management would also benefit other waterbirds such as Chinese Pond Heron which use pond edges for foraging, but also prefer cover.

5.1.4 Approximately 6 weeks after the final vegetation treatment, a lower usage of the bund areas by Anatidae was observed once vegetation became tall, dense and impenetrable. A single one-off cut of some of the vegetation in mid-winter would create a more useable habitat and could attract greater numbers of Anatidae.

5.1.5 Several centralised areas within the series of Ponds at #20 and #24 should be selected for enhancement with Barnyard Millet. Enhancement works may need to include raising the pond floor to create shallower water depths more suited to Barnyard Millet growth.

5.1.6 The high usage of Sub-ponds #20a and #20c by Anatidae warrants further management to maintain their attractiveness. Therefore it is recommended to sun-bake both ponds every few years to maintain a high water quality standard by oxidizing off accumulated nutrients (mainly defecated material). This practice of fully draining a pond followed by exposure to the sun for up to 10 weeks is a regular management activity in Pond #15 for the benefit of Anatidae and should be replicated.

5.1.7 Consideration should be given to the conversion of the northern portion of Pond #23 to open fresh water habitat. Being contiguous with Pond #20, of an open nature, centrally located and a single continuous water body without internal bunds, this area of Pond #23 could be highly successful in attracting Anatidae. It is noted that although Pond #24 does not currently support large numbers of Anatidae it is well used by many Ardeidae and sizeable flocks (30-40) of the endangered Black-faced Spoonbill (*Platalea minor*) in winter.

5.2 Monitoring

5.2.1 Suggestions to improve Anatidae count data quality and interpretation include:

- Conduct counts at other ponds or *gei wai* to provide a more comprehensive understanding of wintering Anatidae within MPNR. In particular all other sub-ponds in #24, #15a-b, *gei wai* #16/17 and *gei wai* #8.
- Continue to coincide one count per month with the HKBWS monthly Ramsar Site waterbird count to facilitate a better understanding of the wintering Anatidae importance of MPNR in a Deep Bay context.
- Continue to conduct counts at periods of high tide in Deep Bay (it is noted that very few tides over 1.8m coincide with evening count times during October, November or December).
- Record all Spot-billed Duck sightings to taxa/race level to provide information for a currently under-researched area of ornithology in Hong Kong.
- To reduce recorder disturbance a small one-man sized canvas hide should be used for counts at Pond #24.

5.2.2 The vegetation planting trial in 2005/06 produced considerably more meaningful results than in 2004/05. This is undoubtedly due to the planting experience and knowledge gained from the first trial. Repetition of the trial should be considered, perhaps with other vegetation types, because the results are of potential importance for betterment of Anatidae habitat management.

5.2.3 Changes to the bund and bankside vegetation sward composition, brought about by an increased cutting frequency, may affect the number and diversity of Anatidae at the Ponds. Therefore, if resources permit, consideration should be given to carrying out an annual vegetation survey on several of the treated areas to detect any long-term changes.

5.2.4 If a single mid-winter cut of bund and bankside vegetation is undertaken (refer to section 5.1.4), Anatidae numbers and usage should be monitored before and after treatment on the affected areas.

6. CONCLUSION

6.1 The combined results from the two vegetation cutting trials in winter 2004/05 and 2005/06 provide strong evidence that freshwater pond bund and bankside habitats can be enhanced to attract greater numbers of roosting Anatidae through the implementation of a more frequent vegetation cutting regime in the preceding months before wintering Anatidae arrive.

6.2 Despite the unfortunate, but necessary omission of 39.7% of the observation period data, the vegetation planting trial provided useful and meaningful results for the future management of internal freshwater pond vegetation for roosting Anatidae. The results not only highlight the potential importance of Barnyard Millet, but also the relative unattractiveness of Water Spinach and Rice Grass to Anatidae. In addition, valuable first hand agricultural experience and knowledge has being gained, which can be applied to enhancement works of a similar nature.

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APPENDIX I – Vegetation Cutting Works

1. Cutting bund vegetation between Sub-ponds #24e and #24f

2. Bund vegetation at Sub-pond #20c before cutting (i.e. 1 month post cut)

3. Bund and bankside vegetation at Sub-pond #24f after cutting

APPENDIX II – Aquatic Vegetation Planting

1. WWF staff planting Water Spinach (#20f)

2. Quadrats in Sub-pond #24f (Nov 2005)

3. Quadrats in Sub-pond #20f (Nov 2005)
   a – Water Spinach
   b – Rice Grass
   c – Knot Grass