Freshwater Macroinvertebrate Survey in the Mai Po Inner Deep Bay Ramsar Site

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Executive Summary

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This tender was awarded in March of 2000, and work commenced immediately. The study had two main aims. The primary aim was to collect baseline information on the freshwater macroinvertebrate fauna in the Mai Po Inner Deep Bay Ramsar Site: almost nothing is known of the ecology of the freshwater habitats within the study area, especially the macroinvertebrates associated with these environments. The lack of information on freshwater wetland invertebrate communities is a world-wide phenomenon. The second main aim was to investigate the use of macroinvertebrates as indicators of organic enrichment in the Mai Po Ramsar Site. There are several potential sources of organic pollution in the study area. Actively managed ponds are nutrient enriched with fertilisers to increase productivity, a practice which undoubtedly affects the invertebrate communities of these ponds, and possibly adjacent ponds too. Additionally, the majority of rivers and streams flowing through the study area are severely polluted. It is possible that pollutants from these rivers will affect lentic freshwater habitats within the Mai Po area. As freshwater organisms respond to changes in their environment brought about by pollution and other factors, they can be used as indicators of environmental quality, or biomonitors. Freshwater macroinvertebrates make particularly suitable biomonitors, and there is an extensive literature on their use in assessing freshwater quality. In this study, we attempted to uncover the relationships between macroinvertebrate community structure and water quality in Mai Po freshwaters. These data would, it was hoped, form the basis of a simple biological measure of organic enrichment in the study area.

In all, 32 fishponds and three rivers inside the Ramsar Site were sampled, with samples being taken in both the dry (September to April) and wet (May-August) seasons. The fishponds selected for inclusion in the survey were chosen to represent the numerous habitats found at Mai Po, from abandoned ponds with abundant standing and floating vegetation, to intensively managed ponds. Sampling was concentrated around the littoral zone, especially emergent and riparian vegetation, where invertebrate richness and density is highest. Invertebrates were collected using a 10in. by 12in. D-framed 500μm mesh sweep-net. Five to 15 minutes sampling effort was allocated to each microhabitat (emergent/floating vegetation, upper sediment layer). Samples were put in plastic bags and preserved with 70% ethanol on site. In addition to sweep samples through vegetation, sediment samples were taken at each site by dragging a sweep net through the upper sediment layers. However, as the abundance and diversity of macroinvertebrates in this microhabitat was generally very low, sediment samples were excluded from further analysis. As well as investigating lentic habitats, three rivers and streams in the study area were also sampled. Artificial multi-plate samplers were deployed at the sample sites, and collected four to six weeks later. All three lotic sampling sites were excluded from detailed analysis, as they were found to be tidal, and therefore brackish.

Water samples were collected once from each site during both seasons, and measurements of water nutrient levels, oxygen concentrations and other parameters were taken. Aside from water chemistry, other habitat characteristics variables of each sample site, such as the extent of emergent and floating vegetation, were also recorded.

In total 34,664 individuals from 173 macroinvertebrate morphospecies were collected during the course of the study. Overall, samples were dominated, in terms of both biomass and abundance, by relatively few taxa. Dominant taxa included thiarid snails, palaemonid shrimps, Hemipterans, dragonfly nymphs, and chironomid larvae.

The habitats at Mai Po did not support many locally rare taxa, but were especially rich in libellulid dragonfly larvae. Compared to other freshwater wetlands in Hong Kong, fewer species of ceratopogonids, tipulids, caddisflies and mayflies were recorded, indicating that the sites were organically enriched.

In many cases, the impact of human activities on the habitats sampled was readily apparent. Actively managed ponds tended to support species-poor communities, and were dominated by palaemonid shrimps and thiarid snails. Less intensively managed and abandoned ponds

supported much richer communities, with free swimming Hemiptera, Odonata and nematocerid Diptera being especially abundant.

Seasonal changes in the communities found in most ponds were dominated by changes in the relative abundance of taxa common in both the wet and dry seasons (e.g., *Agriocnemis* U1, *Diplonychus rusticum*, palaemonid shrimps), rather than the presence or absence of taxa in different seasons. Overall, taxon richness in both managed and unmanaged ponds tended to be higher in the dry season. Extremely large seasonal changes in the invertebrate communities of some ponds were noted, but these were attributed to human activities (such as management) rather than natural changes.

Studies of community structure generally yield large species/sample matrices, in which it can be hard to identify patterns in the data. Multivariate analysis techniques are a group of statistical methods that are ideally suited to simplifying and identifying trends in such data. Three multivariate techniques were applied in the present study: ordination, classification and indicator species analysis. These techniques revealed a number of factors that appeared to influence macroinvertebrate community structure in Mai Po freshwaters. Of these, the intensity of management had a dominant effect. Multivariate analysis divided the ponds sampled into two broad groups. One group largely comprised unmanaged ponds with extensive stands of vegetation. These ponds supported relatively species rich communities. The second group consisted of intensively managed ponds with sparse vegetation. They contained few macroinvertebrate taxa, and palaemonid shrimps (*Macrobrachium* and *Leptocarpus*) overwhelmingly dominated the communities.

In the present study no strong relationships were found between chemical indicators of pollution and macroinvertebrate community structure. This is probably because water quality was uniformly bad throughout the study area, with ammonia concentrations being particularly high in both managed and unmanaged ponds. There are numerous heavily polluted streams and rivers running through the study area. Previous studies in Hong have noted that wetlands adjacent to polluted bodies of water tend to have poor water quality as well. Given the small size of the study area, it is possible that the majority of ponds are affected to some extent by polluted water from nearby streams, regardless of whether they are managed or not. A comparison of the water chemistry of ponds in the Mai Po area with wetlands elsewhere in Hong Kong suggested that freshwaters throughout the study area were organically enriched. Ammonia concentrations in the ponds at Mai Po were approximately 10 times higher than at other wetland sites around Hong Kong. Conversely, taxon richness was considerably lower at Mai Po compared to other wetlands around Hong Kong: two to five times as many taxa were found at other wetland sites when compared to the Mai Po Area.

Because water quality was poor in the majority of sampled ponds, other factors related to management practices determined the differences in macroinvertebrate community structure observed in the study area. Such factors included predation by farmed fish, the removal of standing vegetation, and the regular draining and liming of ponds. These findings posed two difficulties when trying to develop a biomonitoring programme for the study area:

a) When biomonitoring, it is important to have a set of reference sites that are unimpacted or minimally impacted, to which impacted sites can be compared. Organic enrichment affected all ponds in the study area, and as a result, no suitable reference sites were available.

b) The community composition of managed and unmanaged ponds was very different. As a consequence, it was impossible to develop a biomonitoring programme which incorporated both habitat types.

A possible solution to these problems was to treat the two groups of sites - managed and unmanaged - separately. Multivariate analysis could then be employed to identify the least polluted sites in each of these groups, and the communities in these sites used as a reference to which more degraded sites could be compared. To this end, further analysis was carried out, treating the two groups of sites (managed and unmanaged) separately. When analysed in this manner, multivariate analysis split both groups of ponds into three clusters. Again, organic pollution did not appear to be important in determining the communities found in these groups. Salinity and pH appeared to influence the communities in unmanaged ponds, whereas no clear differences between the three groups of managed ponds were found. It was concluded that organic pollution from rivers and streams, and resulting from management practices such as the addition of nutrients to ponds, affected all the sampled ponds to some extent.

Although it proved impossible to devise a biotic index of organic enrichment for the Mai Po area, the long term monitoring of macroinvertebrate communities at Mai Po will allow gross changes in pollution to be detected. It was suggested that the sampling techniques used in this study; sampling the littoral zones of ponds with a sweep net; will prove adequate in any long term monitoring programme. Measures of species richness could serve as a general indicator of long term pollution trends in the study area. This simple metric has the advantage of not requiring detailed keys: taxa can be allocated to morpho-species. In addition to monitoring changes in species richness, a second suggested approach is to look for the presence of sensitive species. Certain taxa common in other Hong Kong wetlands were absent or had a limited distribution in the Mai Po area. Some of these species are regarded as pollution intolerant. A list of sensitive taxa, collated from studies in less disturbed habitats in Hong Kong, is given in section 6 of the report. The establishment of these taxa in the Mai Po area would point to a general improvement in water quality.

行政摘要

本顧問研究合約於二零零零年三月簽訂生效，爲期十二個月。研究主要有兩個目的：最重要是收集米埔后海內灣拉姆薩爾濕地內淡水大型無脊椎動物的背景資料，因爲我們對於研究地區內淡水濕地的生態，尤其是大型無脊椎生物，幾乎一無所知，這現象在世界各地相當普遍。其次是爲了調查如何利用大型無脊椎生物作生物監測，指示研究地區受有機物污染的情況。目前研究地區內的有機污染源有幾個，首先是區內的養魚戶，爲了增加魚產量而加肥料，影響到魚塘內大型無脊椎動物的群落，更可能波及附近的魚塘。此外，流經研究地區的溪澗，大部分的污染情況嚴重，可能對米埔地區的淡水生境造成影響。由於污染物改變了環境，一些淡水生物的反應，可以作爲監測環境質素的指標，這又稱爲生物監測。在利用淡水生物作生物監測方面，科學界已經做了很多研究，是次研究，我們嘗試找出米埔地區大型無脊椎動物群落結構和淡水水質的關係，希望研究出一套簡單的生物監測方法，監測區內有機污染的情況。

研究員在旱季 (十月至四月) 和雨季 (五月至九月) 期間，分別在拉姆薩爾濕地內三十二個魚塘和三條溪流採樣，採樣地點代表了米埔的多種生境，包括廢置後長滿植物的魚塘，和仍然投產的魚塘。採樣點集中在沿岸地帶，尤其是無脊椎動物種類和數量較豐富的挺水和河岸植被。我們利用 10 寸乘 12 寸的 D 框 500 微米網目抄網，採捕無脊椎動物，每一微生境 (包括挺水、漂浮植被和沉積層頂部) 的採樣時間約爲五至十五分鐘，樣本即場收集並儲存在 70%乙醇內。除了在植被間採捕，我們亦把抄網拖過沉積層頂部，收集沉積物的樣本，其後由於沉積層內的物種較少，有關數據並無進一步分析。除了靜水生境外，我們還分別在研究地區內三條溪流內，放了多層碟採樣器，四至六個星期以後收回，其後，我們發現這些溪流都受潮汐影響，因此有關數據並沒有詳細分析。

在旱季和雨季，我們分別在每一個採樣點收集水樣，量度水中養份、含氧量和其他參數，及記錄每個採樣點的生境特徵，如挺水植被和漂浮植被的範圍。

研究期間，我們共採得 173 個大型無脊椎動物的形態種，包括 34,664 個個體，其中大部份的生物量和數量，由幾個分類單位壟斷，這些包括跑螺科、長臂蝦科、半翅目、蜻蜓若蟲和搖蚊幼蟲。

結果顯示，米埔的生境內本地稀有的物種不多，但蜻科幼蟲特別豐富。和香港境內其他淡水濕地比較，米埔錄得較少石蠅、蜉蝣、蠓科和大蚊科的昆蟲，顯示有機物含量較高。

人的活動對於米埔生境的影響，十分明顯。我們發現積極管理的魚塘，物種一般比較貧乏，而且多爲跑螺科和長臂蝦科，而疏於管理或已廢置的魚塘，物種則比較豐富，尤以半翅目、蜻蜓目和雙翅目長角亞目的數量特別高。

由旱季到雨季，季節的轉換影響了一些全年常見物種 (如 *Agriocnemis U1*, *Diplonychus rusticum*, 長臂蝦科) 的相對數量，但沒有導致物種的消失或出現。總的來說，在旱季裏，無論有人管理還是無人管理的魚塘，物種數量和種類都比較豐富。某些魚塘錄得顯著的季節性差異，相信是受到人爲活動 (如管理措施) 而非自然變化的影響。

由於涉及群落結構的數據極多，我們利用多變量分析方法，來簡化和識別數據的分佈趨勢。我們一共使用了三種多變量分析：排序、分類和指示動物分析，識別出幾個因素，其中以管理活動的強度，最明顯影響米埔淡水大型無脊椎動物的群落結構。多變量分析的結果，把魚塘分爲兩大類：一是無人管理並長滿植物的塘，物種比較豐富；二是積極管理的魚塘，植被較稀疏，錄得的大型無脊椎動物物種較少，而且絕大部份爲跑螺科和長臂蝦科。

本研究並無顯示污染物的化學指標和大型無脊椎動物的群落結構之間，有密切關係，這可能是因爲研究地區的水質普遍較差，無論是有人管理還是無人管理的魚塘，水中的氨含量都甚高。此外，由於研究地區面積小，區內大部分魚塘的水質，已經受到附近許多嚴重污染的溪流影響，這種情況，在香港其他地區也有出現。比較米埔的魚塘和香港其他濕地水體的化學成份，我們發現前者有機物含量高，氨含量也比後者高十倍以上。另一方面，香港其他濕地內的物種數量，比米埔魚塘高兩至五倍。

由於大部分採樣的魚塘水質惡劣，大型無脊椎動物的群落結構，主要受到和管理措施有關的因素，如養魚、清除植被、和定期曬塘活動的影響，因此，在該地區發展生物監測，有以下的困難：

1. 進行生物監測，需要一些不受污染或低污染的參考地點，和受影響地點比較，但是研究地區內所有魚塘都會受到一定程度的有機物影響，沒有適合的參考地點。

2. 有人管理和無人管理的魚塘，群落結構差別很大，因此無法發展一套適用於兩種生境的生物監測計劃。

要解決以上問題，可以把有人管理和無人管理的魚塘，分開兩組處理，利用多變量分析，找到每組最低污染的魚塘，和其他污染程度較高的地點作比較。我們進行了多變量分析，結果把每組分爲三大群，在無人管理的魚塘一組，群落結構似乎受到鹽度和酸鹼度的影響，但在有人管理的魚塘一組，卻沒有明顯的分別，有機物的含量對於兩組的結果都沒有明顯影響。總而言之，研究地區內所有採樣點，都受到一定程度的有機污染，這些污染源來自附近的溪流，和魚塘的管理活動。

雖然本研究無法爲米埔地區發展出一套監測有機污染的生物指數，但對大型無脊椎動物的群落結構進行長期監測，可以反映污染情況的大概趨勢。長期監測的採樣方法，可以參照本研究，即利用抄網在沿岸地帶採捕無脊椎動物，至於衡量單位，可以採用分類單位的數量，這是個比較簡單的方法，可指示研究地區的長期污染趨勢。此外，一些在香港其他濕地很常見的生物，從未在米埔錄得，或只在很少地點出現。有些生物在受污染的環境無法生存，我們建議利用這些敏感物種，監測污染程度的改變。本報告第六章，根據其他濕地的研究結果，列出一些對污染敏感的分類單位，如果在米埔的長期監測中錄得這些生物，即表示米埔的水質已經大致改善。