De novo, neste número, incluímos investigação e propostas ligadas à proteção da Natureza. De novo com o fato de que quem de direito se lida por elas interessar pois, discutindo de abusos e maus usos, apregoamos que quem se arroga direitos, cumpra os deveres. De novo, com a esperança de que, acenando agora o estandarte da tradição, se desperte o orgulho de comunidade e se salve o que tão inconscientemente se descruzou.

Cada dia nos chegam notícias dos milhões que se gastam para recuperar uma paisagem degradada ou salvar uma espécie em perigo. Desperdiço ilógico, pois os actos que a tal levaram, na maioria dos casos, foram conscientes e trouxeram lucro apenas a muitos poucos! Não teria sido tão mais fácil prevenir? Não poderemos nós perever?

Pois bem, de novo a Sociedade Alfonso Chaves tenta cumprir a sua função na sociedade dos Açores, alertando à sua maneira para a urgência de uma acção concertada para salvaguardar do nosso património natural que é, de facto, um pouco de cada um de nós.

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THE FORMER MARSH AT PAUL, PRAIA DA VITÓRIA, TERCEIRA, AÇORES, AND THE CASE FOR THE DEVELOPMENT OF A NEW WETLAND BY REHABILITATION OF THE QUARRY AT CABO DA PRAIA

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ABSTRACT

There were once large wetlands at Paul and Belo Jardim, Praia da Vitória, Terceira. Urban development and related pressures have resulted in their progressive destruction, probably since about 1929. Today, all that remains is a small, tidally replenished, pool at Paul and a drained Juncus acutus stand at Belo Jardim. A general description of the present status of these two sites is given herein. The two locations retain little conservation value, although the pool at Paul has historic and heritage significance and should be conserved within larger plans for the development of its former, broader, location as a public recreational and amenity facility.

During the course of this study, a new wetland was discovered within a largely worked out portion of the quarry at Cabo da Praia, just south of Praia da Vitória. Following but a few years disuse, a coastal wetland, attractive to wading birds and reminiscent of the situation that was once prevalent at Paul, has become established. A description of the present, basic, structure, hydrology and ecology of the quarry is given and a case is made for its rehabilitation as an Açorean wetland, so that the former significance of Paul can be sustained. Elsewhere, quarry rehabilitation has been shown to be effective for wetland conservation and suggestions are made as to how this might be achieved locally.

RESUMO

Existiram outrora extensas zonas húmidas no Paul e Belo Jardim, Praia da Vitória, Terceira. O desenvolvimento urbano e as pressões com elas relacionadas resultaram na destruição progressiva daqueles zonas, provavelmente desde 1929. Hoje, tudo o que resta é uma pequena poça reabastecida pela maré, no Paul, e uma mancha drenada de Juncus acutus no Belo Jardim. Aqui apresenta-se uma descrição geral da situação actual desses dois sítios. Os dois lugares têm pouco valor para conservação, embora a poça no Paul tenha significado histórico e patrimonial e deva ser conservada dentro de um plano mais alargado de desenvolvimento da sua localização primitiva, mais extensa, como local público de recreação e parque de diversões.
INTRODUCTION

Santos et al. (1995) review the potential for coastal conservation in the Açores, in broad terms, identifying for each of the nine islands, sites which might serve such a purpose. In more detailed studies of Açorean coastal wetlands, Morton & Tristão da Cunha (1993), made the case for continued protection of the lagoon at Santo Cristo, São Jorge, while Morton et al. (1995; 1996) make similar cases for the protection of Fajã dos Cubres, São Jorge and Lajes, Pico. Morton et al. (1997) have reviewed the case for coastal wetland conservation in the Açores, using the above locations as examples of areas worthy of either continued or new legislative protection. Such legislation has, for example, already been enacted for Fajã dos Cubres and Fajã do Santo Cristo, the former as a Partial Nature Reserve (Decreto Legislativo Regional N° 484/A) and the latter as a Special Ecological Area (Decreto Legislativo Regional n° 889/A), but not for Lajes do Pico.

Despite the protection afforded, access to Fajã do Santo Cristo has been facilitated recently by the widening of the coastal trail sufficient to accommodate all-terrain vehicles. Similarly, a visit by the senior author to Fajã dos Cubres in the summer of 1997, revealed extensive damage to this fragile ecosystem. The path to the lagoon at the side of the church and in front of a row of village houses had been sealed and a concrete dock constructed into the lagoon across the shallow Ruppia maritima platform to the edge of the drop-off into the lagoon itself. All the fringing Juncus acutus had been cut and burned. Most of the elements of the complex botanical community associated with the marsh (Morton et al., 1996) had also been destroyed. Workers were in the process of widening and sealing the two causeways connecting the lagoon sides and central islets. The purpose of the ‘development’ is apparently to provide a dock facility for recreational rowing boats and better access to the central islets. The consequences of such ‘development’ are grave. The lagoon community had suffered a severe ecological blow. The Ruppia population had been reduced by about 80% percent, with that which remained in evidence, either dead or dying. Unlike in 1995 (Morton et al., 1996), no coastal birds were seen in 1997. Only the prawn Palaeomon adsersus was present in numbers comparable to that observed previously. The amphipods Talitrus saltator and Gammarus locustus and the isopod Sphaeroma serratum were still present underneath stones fringing the lagoon shore, but the fate of these species and the few other survivors of the ‘improvements’ to the lagoon at Fajã dos Cubres awaits the next onslaught, perhaps reminiscent of the pattern of destruction that has befallen other natural areas in the Açores.

The modern assault upon the lagoon at Fajã dos Cubres is matched over an even longer time scale by the progressive destruction of marsh habitats at Paúl and Belo Jardim near Praia da Vitória, Terceira. The larger Paúl marsh originally occupied several hectares in a coastal valley beside a fault escarpment and behind a large coastal sand dune (Fig. 1). The latter, in turn, accumulated at the other end of the enormous, in Açorean terms, three kilometre-long sandy beach which, even today, fringes the shore at Praia da Vitória and extends to Belo Jardim. Its light-coloured, carbonate-rich, sands attract locals and tourists on sunny days as an important recreational venue. The Paúl marsh, in its fullest expression, was favoured by many birds, with most historical records of Açorean wading species derived from this site (Bannerman & Bannerman, 1966).
FIG. 1. A photograph of the marsh at Paul, probably taken in the 1920s or 1930s. (Courtesy of Francisco Jorge Lopes, Procurador da Santa Casa da Misericórdia de Vitoria, Vitoria, Terceira).

GEOLICAL SETTING

The Terceira Rift, generally considered a secondary spreading centre in the Azores, is a result of the extension of the Carlsberg Rift, which is a continuation of the Mid-Atlantic Ridge. The Terceira Rift is characterized by a series of faults and fractures that have allowed the formation of Kidd and Pinheiro, two prominent peaks, and the subsidence of the Alcântara basin, which is located on the eastern side of the island.

THE PRACA DA VITÓRIA - TERCEIRA

The surviving marsh at Paul, Vila Franca do Campo, is located on the western side of the island, adjacent to the Terceira Rift. The marsh is characterized by a vast area of shallow, unvegetated, and sandy substrate that is bordered by a series of Elevado ridges separated by shallow troughs. The island is often flooded by the sea, which is characterized by a thin veneer of calcareous deposits upon the Alcântara formation.

SCENE, 1890. Amours Micronials, a submarine topographic high that rises above the Alcântara formation, is the source of the island's geothermal activity. The island is composed of pillow basalts and tuff, which are erupted from the sea floor and form the volcanic edifices of the island. The Alcântara formation, which is composed of a series of reefal limestones, is located in the interior of the island and is characterized by a series of fossilized marine organisms.
western flank has become an elevated wasteland dominated by the Castor bean *Ricinus communis*. The *Juncus acutus* component of the marsh lies to this side and is separated from the pool, lying on agricultural land, by barbed wire fences. Here also are many of the plants observed at other Açorean marshes, especially the Spear-leaved orache *Atriplex hystata*, but also Sea bindweed *Calystegia soldanella*, Watermin *Menihia aquatica*, Bramble (blackberry) *Rubus fruticosus*, Wild parsley *Petroselinum crispum*, Marsh dock *Rumex hydrolapathum*, the Sea beet *Beta vulgaris* and sparse stands of Seaside spinach *Tetragonia tetragonioides*. Several seiges stand amongst the other vegetation, most prominently Yellow nut grass, *Cyperus esculentus* and the American rush, *Scirpus americanus*. Here also occurs the Slender rush *Juncus tenus*, apparently recruited, like the two preceding seiges, from North America. The grass, *Holeus lanarius*, protected from livestock along the northwestern side of the pool by the fences, grows tall, producing large, showy, inflorescences. The same grass carpets the south-eastern flank of the pool, just beyond

a muddy fringe disturbed by livestock, but here it takes the form of a prostrate creeper under the pressure of grazing. Interspersed among the cropped grass are solitary plants of Spear-leaved orache, *Atriplex hystata*, Ribwort plantain, *Plantago lanceolata* and young *Juncus acutus*.

The pool component of the marsh comprises a shallow, 50 metre-long, strip of water whose lateral dimensions change with the tide. The salinity of the water here was 34%, determined on a rising tide and with no rain for the past few days. In the summer, at least, the surface of the pool is covered with a mat of *Enteromorpha intestinalis* and *Chaetomorpha linum*. Swarms of the ephydrid fly *Pistiona nitidula* crawl upon the algae and the surface of the water, making only short flights, even when disturbed. Fly pupae occupy the mud on the floor of the pool amid a few tiny *Assimineia elata*, recorded only from Terceira (Backhuys, 1975). Also here, under mats of algae and the few stones, was the amphipod *Talirus saltator*. When visited during a summer day, one Kentish plover *Charadrius alexandrinus* was feeding on the flies but, at dusk, three Coots *Fulica atra* had emerged from the *Juncus* and were also feeding on the pool. We observed a similar pattern in October, with one less Coot. Typically shy birds, they retreated quickly. The present poor status of the avifauna at Paúl reflects how significantly the marsh has deteriorated from its once proud reputation as the premier haven of Açorean wading birds (Agostinho, in Bannerman & Bannerman, 1966). When the marsh was much more extensive, it supported, for example, a large population of small Mullet *Chelon labrosus* which local fishermen used to catch when tangeing to sea was a hazard.

THE MARSH AT BELO JARDIM, PRAIA DA VITÓRIA, TERCEIRA

Although some Terceirans are trying to preserve the pool and remnant *Juncus* community at Paul, its fate is as uncertain as that of a second *Juncus* marsh at Belo Jardim, on the opposite side of the city of Praia da Vitória. Once part of what would have been an ecological continuum with Paul, and which Agostinho (in Bannerman & Bannerman, 1966) described as a continuous marsh from Paul to Ponta das Candelas, the marsh at Belo Jardim also occupied lowlands and a lagoon behind a large, 300 metre-wide, sand dune field near the southern terminus of the Praia da Vitória beach. This marsh was replenished at each tide by percolation of seawater through the loose sand, although it would also have received freshwater from rainfall and groundwater delivered from the adjacent highlands. Agostinho reported that gulls, terns and Kentish plovers roosted there as did visiting Lapwing *Vanellus vanellus*, Grey plover *Pluvialis squatarola*, Curlew *Numenius arquata* and Sanderling *Calidris alba*. Kentish plovers nested in the dune field.
The present Juncus marsh at Belo Jardim is considerably larger than that at Paúl, occupying at least 100 m² (Fig. 3). It appears, at least superficially, to be surviving but, in reality, its condition is, at best, precarious. The dune which once protected it has been removed and the marsh has been drained. Today, it is wetted only by rain which, except during the wettest winter storms, drains away quickly. As a consequence, although the Juncus plants survive, there is no other aquatic biota. The sole voice of a resident Quail Coturnix coturnix emerging from within the maze of Juncus attested to its dryness and predominantly terrestrial nature as did the chirping of the Common field grasshopper Chorthippus brunneus. Several significant plants in addition to the Juncus are here, however, especially the Spear-leaved orache Atriplex hastata. Seaside spinach Tetragonia tetragonioides is more abundant here than at Paúl. As at Lajes do Pico, there is a second common rush, the bright green Juncus maritimus scattered among the Juncus acutus. The deadly poisonous Thorn apple Datura stramonium has invaded otherwise bare ground on the interior of the marsh, again attesting to the transition of this one time wetland to a terrestrially dominated habitat. The exotic Russian thistle, or Tumbleweed, Salsola kali, with its numerous, sharp, prickles, dots low sand banks: all that remains of the once tall dune field which fringed the former marsh.

Like its contemporary at Paúl, the present stand of Juncus at Belo Jardim is a poor reflection of what once was a part of the most significant Açorean wetland. We have, however, discovered a third, emerging, wetland within a quarry outside the city of Praia da Vitória.

THE QUARRY AT PRAIA DA VITÓRIA, TERCEIRA

The construction of the harbour at Praia da Vitória necessitated quarrying large quantities of rock. This was initiated in 1983 at Cabo da Praia, south of the city, just beyond Belo Jardim. When landing at Terceira's Lajes airport from Praia da Vitória, the quarry is evident from windows on the left side of the aircraft, appearing as a rectangular precipitous escarpment surrounding a 300 m x 500 m scarred and sparsely vegetated bowl with large trucks entering and departing (Fig. 4). Its southern half appears greener and to have been worked out and abandoned, although it is now being used as a dump for construction debris, soil and household rubbish (Fig. 5). The reasons for the green in the quarry were investigated in July, August and October, 1997. At first, this portion of the quarry, approximately half of the entire site, seems unpromising and unproductive, its ledged cliffs rising some twenty metres above the excavated floor and terminating, seaward, on the original, coastally-eroding, platform from which the quarry was dug. The landward, northwestern, portion of the quarry is still being used and here, with little vegetation, it resembles a boulder field on Mars.

The construction of the harbour and the Cabo da Praia quarry which facilitated it led to a number of mistakes in the absence, presumably, of a scientifically responsible environmental impact statement. The first was that the fate of the Juncus marsh at Belo Jardim was largely sealed. As the port and its associated activities grow, that marsh will disappear — it is already largely a reflect. Second, at its southeastern end, the quarry was excavated too close to the sea. An even cursory examination of the original ledge presently separating the sea from the quarry floor reveals that its seaward face is actively eroding, probably facilitated by winter storms, with soil and rocks from it falling onto the coastal boulder shore below. The third mistake was that this end of the quarry was dug too deeply, penetrating the coastal water table. Each rising tide on the adjacent seashore pushes estuarine groundwater into the base of the quarry, partially filling depressions therein.

The collective consequence of these mistakes is that a unique Açorean wetland has been created, allowing the people and the government of Praia da Vitória to assimilate
their consciences (where and if they exist) over the virtual loss of the formerly most significant marsh in the archipelago. The remains of the Juncus marsh at Paúl da Praia can now become what it actually is, a village pond, reminding every Terceiran resident of his and her coastal and cultural heritage. It can never again be a true wetland because it has been reduced to insignificant proportions. No matter. An accident of industry has created Paúl's successor, a wetland of manageable size in government-owned land that already has in place all of the infrastructural necessities for survival and public access.

The seaward ledge which surrounds that part of the quarry is characterized by scrub and the Cane Arundo donax. There are also Tamarisk trees, Tamarix gallica. This vegetation also fringes the internal ledges of the quarry cliffs and has invaded what appears to have been the quarry workmen's huts but, now, consists of a few tumbled brick buildings along the seaward margin of the quarry. In a few places, the Cane has already invaded the quarry floor. The floor itself comprises much dumped refuse and irregularly-terraced, boulder-strewn, crumbled ash depressions and elevations. These depressions flood with water periodically and, in so doing, interconnect to form broad, shallow, pools (Fig. 6). On spring tides, the entire floor of the southeastern end of the quarry floods to form a shallow lake.

Hydrology of the quarry pools

It is clear that the pools of the Cabo da Praia quarry are filling and emptying in rhythm with the tide, that is, flooding at high tide and draining on the ebb. The salinities of 16 pools were examined over a period of three days in July and August and one day in October at different tidal elevations, except low, when most of the pools drain. Salinity values ranged from between 21-28% (Table 1). Little variation occurred between the individual pools, although there is the suggestion that those at highest elevations (lower numbers) were slightly less saline (21-22%) than those at lower ones (higher numbers) (27-28%). Similarly, although the average salinity of the pools (25%) varied little between falling, rising and flood tides, there is again the suggestion that the average salinity was slightly higher (25.4%) than at the time of the falling tide (24.6%). The salinity at the low ebb tide could not be measured because, at this time, the pools are largely drained.

We interpret these data to argue that a cell of groundwater occupies the porous spaces between rocks lining the bed of the quarry. It almost certainly varies in salinity with the frequency and duration of rainfall and groundwater supply from the land, probably being less saline apically and more saline basally, that is, a freshwater input settling on top of the marine one, accounting for the slight discrepancy in salinity values.
between high and low elevation pools. This cell of water is pushed upwards by the hydrostatic pressure of the rising tide, eventually emerging from fissures and crevices in the quarry bedrock to flood much of its floor. As the tide ebbs, the water drains back into the rock.

Ecology of the pools at the Cabo da Praia quarry

Because the quarry floor depressions will be filled to an 'average' level over the course of a lunar year and higher elevations only on spring tides, a simple pattern of 'intertidal' zonation has emerged around them. Moreover, a few of the pools, or portions of them, do not drain entirely. Patches of *Ruppia maritima*, recorded previously from the Açores only from São Jorge (Hansen & Sunding, 1985), in the lagoon at Fajã dos Cubres (Morton et al., 1996), occur in these pools (Fig. 7). The vegetation surrounding the pools displays a distinctive zonation pattern. The Cane *Arundo donax* occupies higher ground at the quarry edges. Between adjacent tall plants and even within rusty, abandoned, oil drums the large yellow and black spider *Argiope bruennichi* builds large orb-shaped webs. The cane is succeeded at lower levels, virtually everywhere, by the thin, erect, grey-green, Jersey cudweed *Gnaphalium luteofolium*. Below this, a dense bed of the Spear-leaved orache *Atriplex hastata* fringes the pools just above the influence of the highest spring tides. Lower still and covered by most average tides is another dense bed of vegetation consisting entirely of the Lesser sea spurry *Spergularia marina*, a delicate, low, fleshy, annual with leaves arising in groups up each stem. Tiny, 5-8 mm, five-petaled flowers crown the spikes of most branches. The purple-pink flowers open when uncovered by water in bright sunlight, but close when either immersed or at night. The species has been recorded previously from Terceira, Pico, Graciosa, São Miguel and Santa Maria (Palhinha, 1966), but this is the first record of it as a mat. The fourth plant in this zonation sequence is *Ruppia maritima* occupying the bottoms of the non-draining pools. Elsewhere, however and even in the same pools as *Rup-
The only invertebrates recorded from the quarry pools were the amphipod *Orchestia mediterranea*, under stones, three species of tiny prosobranch gastropods, *Assiminea eliae* (Backhuys, 1975), an unidentified species of *Assiminea* and *Pseudinella litorina* and the fly *Psilopa nitida*, its eggs and pupae resident in the mud and algal mats. The red dragonfly *Sympetrum fonscolombi* was patrolling the ponds hunting flies. This community is similar to that at Paúl da Praia, suggesting ecological continuity between the two.

**Birds**

The true wonder of the quarry lagoon, however, is its avifauna, which, in its albeit reduced richness, stands out against the paucity of birds at Paúl da Praia and Belo Jardim and, further, recalls the former richness of the Paúl marsh remembered by Agostinho in Bannerman & Bannerman (1966) and, from here and elsewhere in Terceira and the Açores, by Le Grand (1983). The latter recorded 24 species of breeding birds from Terceira, including Cory’s shearwater *Calonectris diomedea*, the Kentish plover *Charadrius alexandrinus*, the Common snipe *Gallinago gallinago*, the Herring gull *Larus argentatus* and the Common and Roseate terns *Sterna hirundo* and *Sterna dougallii*, respectively. Most significantly, the marsh at Paúl was home to the endemic Açorean Moorhen *Gallinula chloropus correiana*, but which, with the demise of the marsh at Paúl da Praia, is probably now locally extinct (Agostinho, in Bannerman & Bannerman, 1966).

Today, the quarry cliffs are home to hundreds of Rock doves *Columba livia*. Also present in the quarry were the Canary *Serinus canaria*, the Black cap *Sylvia atricapilla*, the Goldfinch *Carduelis carduelis*, the Blackbird *Turdus merula*, the Starling *Sturnus vulgaris*, the Grey wagtail *Motacilla cinerea* and the ubiquitous House sparrow *Passer domesticus*. Such birds are seen everywhere in the Açores but it was the seabirds which were a surprise.

Over a period of three days in July 1997, the following species were recorded from the quarry. Common terns *Sterno hirundo* and Roseate terns *Sterno dougallii* washed themselves and roosted on favoured, so soiled, pool rocks. There were two Whimbrel *Numenius phaeopus* and the site was being used as a roosting site by three Grey heron *Ardea cinerea* and, surprisingly, one Little egret *Egretta garzetta*. Single individuals of Sanderling *Calidris alba* and Green sandpiper *Tringa ochropus* were identified. There were pairs of Little-ringed plover *Charadrius dubius* and juvenile Grey plover *Pluvialis squatarola* present and flocks of approximately 12 Turnstones *Arenaria interpres*, turning stones and the dried algal plaques presumably in search of amphipods, and approximately 30 Kentish plover *Charadrius alexandrinus*, feeding on the flies. The flocks of both the latter species comprised adults and first summer birds, that is, those hatched

**FIGS. 7-8.** The wetland at Cabo da Praia. 7, *Ruppia maritima*; 8, sulphur bacteria.
the previous calendar year. Turnstones do not breed in their first summer and remain far south of the breeding grounds (Hayman et al., 1986). The presence of so many species attests to the newly discovered significance of the quarry and is a good reflection of what Agostinho (in Bannerman & Bannerman, 1966) recorded from the lagoon at Belo Jardim in the 1960’s. The most interesting record from the quarry, however, was three individuals of the Black-tailed godwit Limosa limosa in breeding coloration, with a characteristic russet-coloured head and white underparts flecked with black. They were busy feeding, by probing, in the Atriplex hystata beds with their stout bills. Le Grand (1983) regards this species as a ‘fairly common’ winter visitor to the Açores although Bannerman & Bannerman (1966) think that it reaches the islands in ‘some numbers’.

In a return visit to the quarry in late October 1997, an even bigger avian surprise was present. In addition to Herring gulls, there were three Black-headed gull Larus ridibundus, albeit in winter plumage and, thus, with a white head. 40 Common terns and two roseate terns. There were four Grey herons, two Little egrets, one Wimbrel, a flock of 30 Kentish plovers, some 20 Turnstones, six Grey plover in winter plumage, a flock of over 100 Sanderling and some 20-30 Little-ringed plover. Additional species recorded were eight Bar-tailed godwits Limosa lapponica, seven Knot Calidris canuta and five Dunlin Calidris alpina, all in winter plumage, and two female Mallard Anas platyrhynchos. It was apparent that the roosting gulls and terns were using the quarry regularly and further that the resident and visiting waders were here feeding (Fig. 9). Although disturbed by our presence, they did not fly away but moved from one part of the quarry to the other. The autumn visitors, in particular, typically seen in the Açores as solitary individuals, were here as small flocks and clearly identified with the quarry and its various contained habitats. In the absence of Juncus, however, no Coots were recorded from the quarry.

DISCUSSION

In the introduction to this paper, we identified coastal areas and habitats of the Açores and their species that have been proposed for protection and conservation. In particular, we support all the suggestions of Santos et al. (1995), albeit with the provision that there is the possibility for flexibility with regard to different degrees of protection. For example, the sheer inaccessibility of the sea cliffs of Ilhéu de Baixo, off Graciosa, is effective in affording protection to the colonies of nesting Common and Roseate terns, both, uniquely, doing so on narrow ledges instead of the more usual coastal platforms. Conversely, as we have described herein, the lagoon at Fajã dos Cubres, one of the most ecologically sensitive and delicate of all local

intertidal habitats (Morton et al., 1995), has, in 1997, been extensively perturbated. It is protected by legislation in theory, but not in practice. This is because the legislation does not have the accompanying regulations and, as a consequence, there is no means to enforce such legislative paperwork. Wetland destruction is, however, a global phenomenon, the word for the habitat too often being equated with ‘wasteland’. It is precisely this attitude that led to the demise of the Juncus marsh at Paúl da Praia on Terceira but, in investigating the remains of this once thriving wetland, we discovered something that gives the conservation of such habitats in the Açores some cause for hope. Before discussing this, however, we wish to point out several features of the Paúl marsh and new wetland at Cabo da Praia.

Morton et al. (1997) have shown that the Terceira wetlands are ecologically fundamentally different from other Açorean wetlands on São Jorge and Pico. This is because, on Terceira, secondary productivity in the two sites seems to be principally based around the fly Psilotreta nitidula and amphipods both being exploited by flocks of Kentish plovers and Turnstones, respectively, whereas at Fajã dos Cubres, for example, it is based around the prawn Palaeomon adspersus. There are very few reports of an aquatic system with a fly-based source of secondary

![FIG. 9. The wetland at Cabo da Praia; high tide, with flocks of roosting birds, in October 1997.](image-url)
productivity. The best known such system is the Great Salt Lake in Utah, USA, where the ephydrid fly *Ephydra cinerea* is often the only benthic metazoan and creates an annual productivity of 50 g.m^-2^ (Collins, 1980). In freshwater Lake Malawi, Malawi, the larvae and pupae of the lake-fly *Cubes epulis*, feed on zooplanktonic crustaceans forming another unique food chain, the ultimate productivity of which is largely exported (Degnbol, 1993; Allison et al., 1996). Of relevance to the situation at Cabo da Praia, however, Barnard (1993) showed that in a rehabilitated gravel quarry pit in England, the removal of fish resulted in an increase in the numbers of chironomid flies and a related increase in the breeding success of the Tufted duck *Aytha fuligula*. The fly at Cabo da Praia is likely the major source of food for the resident flock of Kentish plover. Feeding birds were observed stabbing rapidly at the mud surface on which the flies are the only invertebrates. This may, therefore, be a significant factor in the survival of Kentish plovers as a resident here. Another factor, however, is related to the propensity for the female to abandon her first clutch, leaving the male to hatch and rear it, while she produces a second one with another male which they then both raise. This appears to be unique among wading birds (Szekely & Williams, 1994). Kentish plovers are also highly vigilant, so that the combination of the unique food source, reproductive strategy (also sustaining genetic diversity) and behaviour contribute to its continued survival here as long as the environment support it persists.

We have recorded flocks of Turnstones from other locations in the Açores, for example, Lajes, Pico (Morton et al., 1996). This species has a very catholic diet spanning many habitats (Gill, 1986), but is also recorded to eat flies (Smith & King, 1988). Like Kentish plovers, Turnstones are extremely vigilant (Metcalfe, 1984). The continued survival of the Turnstone in the Açores, therefore, probably relates to its feeding opportunism, the species even being known to destroy tern colonies through egg predation (Lofin & Sutton, 1979), vigilance and, possibly, at Cabo da Praia, a secure roosting site. Here too it was turning stones, the only known occupant of the undersurfaces being *Orchesia mediterranea*. The Kentish plover and Turnstone are the only flocking waders we have observed at a number of locations in the Açores and, as discussed above, there may be good reasons for their continued survival locally. The other species of waders recorded from Cabo da Praia may be either vagrants or summer or winter visitors. Certainly the Dunlin, Sanderling, Knot, Grey plover and Black-headed gull were all in winter plumage. Le Grand (1983) records that the Grey heron *Ardea cinerea* used to breed on Santa Maria. The record of four at Cabo da Praia suggests to us that the species may be resident. Our reports of other birds say nothing of their Açorean status, although the three Coots in the *Juncus* marsh at Pauil suggest that they, too, are still resident.

Morton et al. (1997) have reported on the quarry at Cabo da Praia in more general terms and proposed that it be developed as a wetland reserve, for visitors, students, local community groups and tourists. How could this be achieved? Elsewhere in the world, quaries have been converted, either naturally or deliberately, into new wetland habitat, the most famous being the Sevenoaks, Kent, England Gravel Pit Reserve (Harrison, 1974). Andreas & Host (1983) have shown how an abandoned sandstone quarry in Ohio, USA, has developed into a weakly minerotrophic, freshwater, swamp, over a period of seventy years, based around five species of *Sphagnum* moss and with thirty-five other species of vascular plant present, six of which are on Ohio's rare plant list. Huebner et al. (1986) showed how aquatic birds returned to a rehabilitated inland quarry in Germany and Hill et al. (1987) showed how Mallard *Anas platyrhynchos*, bred successfully in a flooded, freshwater, quarry in England. Jaakson (1981), showed how five disturbed landform quarries in Canada, all close to urban areas, could be developed as outdoor recreational assets for city dwellers. This case study illustrated the positive value of a disturbed landform as a potential amenity in the open space system of a city and its surroundings. The author pointed out, however, that hydrogeology and groundwater movement have to be considered in the process of landscape planning and design. Such would also have to be considered if and when the Cabo da Praia quarry is considered for rehabilitation. More related to the Açorean situation, Street (1976) discussed the ways in which a 300 hectare quarry in England had developed a fourteen hectare bird breeding reserve, particularly for ducks, that is, Mallard and Tufted duck *Aytha fuligula*. This involved the testing of different nesting structures and their sitings to determine their effectiveness. Most recently, Anderson & Brown (1991) studied a limestone quarry in the USA and showed how a half a square hectare of wetland was established on a stressed area of its floor and eventually comprised some 86% native species. All the more significant for the Cabo da Praia situation, however, was the observation that such a plant community had developed on an analogous substratum of a thin layer of topsoil and with fluctuating periods of inundation and flooding.

These studies all point to the potential for quarry rehabilitation as wetland reserves in many parts of the world. It thus seems at least possible that such a rehabilitation could take place at Cabo da Praia. Indeed, from the above description of the habitat which has already developed since work stopped in this part of the quarry, there would seem to be little restitution work necessary, save for, as pointed out by Jaakson (1981),
careful landscape planning within the present groundwater hydrogeographic regime of the quarry. The beauty of this proposal is that it would cost relatively little to achieve: the quarry is government owned, the wetland is essentially already there, the important habitats within it are easily identifiable, there are existing buildings for conversion to a temporary management and education center. There would be an education centre, a guided walk around the cliff edge and within the quarry, bird watching hides strategically placed and a resident manager, wardens and education officers. The development would be seen by government and international fund-awarding bodies as a positive step to replace the original marsh at Praia da Vitória and which can now be allowed to end its existence as a wetland, but perhaps surviving as a village heritage pool. Gracefully, Kusler & Kentula (1990) provide a review of wetland restoration in the United States and provide a set of planning and implementation recommendations for persons and organisations preparing to undertake such rehabilitation work.

Medeiros et al. (1996) continued the search on Terceira for a habitat suitable for the endemic Azorean Mothren Gallinula chloropus correiama. To be able to re-create such a habitat for such a species, if it is not locally extinct (Agostinho, in Ban-nerman & Bannerman, 1966), or, if it is, by the re-introduction of external stocks of the parent species, would give added signification to the whole rehabilitation exercise and provide the quarry reserve with its species flagship.

This paper is also the first report of a Sparganium marina community in the Azores. It is, also, only the second record of a Widgeon grass, Ruppia maritima, community in the Açores (Hansen & Sinding, 1985; Morton et al., 1995). The latter authors pointed out that the Ruppia maritima community at Fajã dos Cubres, São Jorge, was probably established from viable drupelets carried there in the intestines and faeces of wading birds. Bearing in mind, the very recent origin of the Cabo da Praia quarry, the likelihood is that it too was colonised by the seagrass in the same way, probably from Fajã dos Cubres, but a short flight away. The quarry at Cabo da Praia, therefore, is already a significant Azorean wetland.

There is, however, one important constraint to the proposal to establish Cabo da Praia as a rehabilitated wetland. There is already Azorean legislation which prohibits the hunting of sea birds, but such prohibition is, apparently, ignored. We were told, during our October visit, that two "geese" (probably Canada geese, Branta leucopsis) had been shot in the quarry. Legislation would have to be enforced at Cabo da Praia, if the newly-evolving wetland is to stand any chance of re-creating the wading bird environment of its predecessor, Paul. Recognising that hunting constitutes one of the most significant sources of disturbance for waterbirds throughout Europe, Madsen & Fox (1995) pointed out that quarry birds are potentially the most susceptible to disturbance by disrupting pair bonds and family structures to reduce reproductive success. Accordingly, if the quarry was to be developed as a new wetland, it would need not just protective legislation but also wardening and careful scientific monitoring with the gradual development of habitat suitable for the roosting, feeding and nesting of the greatest variety of species.

Throughout the world, community-based action groups, mindful of the destruction of their local wetlands, are either creating or rehabilitating disturbed marshland habitats. The formation of such a group would be a necessary development, too, in Terceira. Morton et al. (1996) also argue the need for the development of an Azorean ornithological society in the great tradition of Col. A. Chaves, Col. J. Agostinho and Al-\varens Cabral, to monitor and record bird numbers and species, especially at the different wetland sites so far identified but, especially, again at the newly-discovered quarry on Terceira. There is also a need for the establishment of a scientific research group dedicated to wetland ecology and which would through its activities and discoveries eventually finding their way into the local public and educational domain, lay the basis for the recognition of the need to protect such, so obviously endangered, coastal Azorean habitats.

ACKNOWLEDGEMENTS

The senior authors are grateful to the trustees of the Sociedade Afonso Chaves, Ponta Delgada, São Miguel, for the provision of finances which made this study possible. The authors are also grateful to Dr. Jorge A.P. Bruno, Instituto Açoriano de Cultura, Angra do Heroísmo, Terceira and Francisco Jorge Ferreira, Provedor da Santa Casa da Misericórdia da Praia da Vitória, Terceira, for hospitality and the benefit of discussions. David Melville (WWF, Hong Kong) kindly commented on our interpretation of the avian fauna of the quarry.

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