

# PHRAGMITES AND CLADIUM ON S'ALBUFERA DE MALLORCA

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NEWBOULD, P. (1995). "*Phragmites* and *Cladium* on S'Albufera de Mallorca". *S'Albufera de Mallorca*. (Monografies de la Soc. Hist. Nat. Balears, 4). Pp. 89-95. ISBN: 84-273-6506-3. Ed. Moll, Palma de Mallorca.

*Phragmites australis* and *Cladium mariscus* are the two most extensive dominant species in the marshes of the Albufera. A preliminary study was made in April 1990 of the above-ground biomass of the marsh vegetation at 10 locations within the Albufera. On 7 sites the biomass of *Phragmites* ranged from 72-792 g dry weight m<sup>-2</sup>, representing 72-99% of the total. At three sites the *Cladium* biomass varied from 18-392 g dry weight m<sup>-2</sup> representing 90-100% of the total. The leaf area index (area of leaf per unit area of ground) of *Phragmites* ranged from 0.5-2.3, of *Cladium* from 1.5-4.3. The morphology and seasonal growth patterns of the two species are strongly contrasting.

*Phragmites* shoots, especially on sites which have not been burned for several years, are attacked by the caterpillar of the moth *Archanara geminipuncta* which causes the death of the apical shoot, encouraging the development of lateral shoots. In some areas more than half the stems are affected.

Further studies on the productivity of *Phragmites* and *Cladium* have been carried out on four sample dates in 1991.

**Keywords:** Biomass, Productivity, *Phragmites australis*, *Cladium mariscus*.

*Phragmites* i *Cladium* són les dues espècies dominants que ocupen la major extensió en els aiguamolls de S'Albufera. S'ha realitzat un estudi preliminar durant l'abril de 1990 de la biomassa aèria de la vegetació dels aiguamolls a 10 localitats de S'Albufera. Dins 7 localitats de biomassa de *Phragmites* oscil·lava entre 72 i 792 g pes sec m<sup>-2</sup> constituint un 72 al 99% del total. A 3 localitats la biomassa de *Cladium* va variar de 188 a 392 g pes sec m<sup>-2</sup> representant de un 90 a un 100% del total. L'índex de superfície foliar (àrea de la fulla per unitat de superfície terrestre) de *Phragmites* va variar de 0.5 a 2.3 i el *Cladium* de 1.5 a 4.3. La morfologia i els patrons de creixement estacional de les dues espècies contrasten fortament.

Les tiges de *Phragmites*, especialment a les localitats que no han estat incendiades durant alguns anys, són atacades per l'eruga *Archanara geminipuncta*, que provoca la mort dels àpex caulinars, provocant el desenvolupament de tiges laterals. En algunes àrees més de la meitat de les canyes en són afectades.

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**Paraules clau:** Biomassa. Productivitat. *Phragmites australis*. *Cladium mariscus*.

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*Phragmites* y *Cladium* son las dos especies dominantes de mayor cobertura en las marismas de S'Albufera. Se llevó a cabo un estudio preliminar en abril de 1990 de la biomasa aérea de la vegetación de la marisma en 10 localidades en S'Albufera. En 7 localidades la biomasa de *Phragmites* abarcó de 72 a 792 g de peso seco m<sup>-2</sup> constituyendo 72 a 99% del total. En 3 localidades la biomasa de *Cladium* varió de 188 a 392 representando un 90 a 100% del total. El índice de superficie foliar (área de la hoja por unidad de superficie terrestre) de *Phragmites* varió de 0.5 a 2.3 y el de *Cladium* de 1.5 a 4.3. La morfología y los patrones de crecimiento estacional de las dos especies contrastan fuertemente.

Los tallos de *Phragmites*, especialmente en localidades que no han sido incendiadas por varios años, son atacadas por la oruga *Archanara geminipuncta*, que causa la muerte del ápice caulinar, promoviendo el desarrollo de tallos laterales. En algunas áreas más de la mitad de los tallos están afectados.

Se han hecho estudios ulteriores de productividad de *Phragmites* y *Cladium* correspondientes a cuatro fechas de muestreo en 1991.

**Palabras clave:** Biomasa, productividad, *Phragmites australis*, *Cladium mariscus*.

## INTRODUCTION

Project Albufera, based in the Parc Natural S'Albufera and promoted by Earthwatch, has been running for two full years, 1989 and 1990 and is ongoing. General accounts of the project are given by WOOD (1989, 1991) and NEWBOULD & RIDDIFORD (1990). A concise account of the history and limnology of the Albufera is given by MARTÍNEZ-TABERNER *et al.*, (1990). The primary objective of the project is to carry out baseline studies which could be repeated from time to time and which would allow the detection and measurement of environmental change. A secondary objective is to provide information to the Park Management Authority which would be useful in the management and interpretation of the Park. The studies are mainly biological, meteorological and hydrological. The biological studies involve the recording of populations of plant and animal species, including vegetation studies.

The predominant vegetation type on S'Albufera is marsh, occupying a salinity gradient with *Cladium mariscus* at the freshwater end and *Arthrocnemum* spp. at the saline end. *Phragmites australis* appears to have a wide ecological tolerance and occurs almost throughout. It seems likely that *Phragmites* and *Cladium* between them contribute a high proportion of the herbaceous plant biomass on S'Albufera. Normal

measures of frequency or abundance applied to these two common species are not very revealing. Their phenology and growth forms are quite different and it seemed desirable to measure biomass, productivity and other performance indicators in different sites, and use these data as the baseline for assessing both environmental heterogeneity and environmental change. The data will also contribute to an understanding of the structure and functioning of the marsh ecosystem. It may, for example, be possible to define the habitat requirements of the Moustached Warbler (*Acrocephalus melanopogon*) in terms of the performance parameters of *Phragmites* and *Cladium*, allowing management to cater for the protection of this important species.

## GROWTH HABIT AND ECOLOGY

Much general information about the ecology of *Phragmites* and *Cladium* has been summarised by HASLAM (1972) and CONWAY (1942) respectively in their Biological Flora accounts of these species. In both cases these accounts refer to earlier research papers.

At S'Albufera both species are subject to occasional burning and there is a cycle of regrowth following this. Hence one factor

influencing performance is probably time since last burn. The above-ground growth of *Phragmites* is essentially annual; the shoots die back each autumn and new shoots arise from the rhizomes each spring. At S'Albufera, as also reported by HASLAM (1972) from Malta, some of the shoots remain viable through the winter and produce lateral branches in the spring, but this is not especially common. Most stems produce a terminal inflorescence. In some areas the stems are widely attacked by caterpillars of the moth (*Archenara geminipuncta*), which bore into the stem and feed on the vascular tissue within the internode resulting in the death of the shoot above that internode. This removes apical dominance and buds are formed below the affected internode, forming two or three side shoots. Although these are much thinner than the original shoot they often produce inflorescences. In some cases the Reed Bunting (*Emberiza schoeniclus*) uses its powerful bill to open up the internode and eat the caterpillar. The incidence of caterpillar damage varies in different parts of the marsh. There is some indication that old stands (in the sense of time since last burn) are more vulnerable than young ones.

After burning *Phragmites* produces a high density of small shoots, sometimes with just a few larger shoots. In successive years the density becomes lower, and shoot diameter comes to have a bimodal distribution, a few thick shoots and a large number of thin ones. The explanation may lie in the structure of the rhizome growth but this has not been examined yet.

In contrast to *Phragmites*, *Cladium* has perennial leaves, each leaf reaching an age of 3-4 years before becoming brown and senescent. Each year new leaves are produced in the centre of the shoot and old leaves die off at the outside. It does not produce inflorescences as freely as *Phragmites*, and a new plant may not flower until its fourth year. However this does not always apply after burning, since some plants flower in the year directly after a burn.

Where horse or cattle grazing has been introduced, *Phragmites* is heavily grazed and *Cladium* would seem to be a fodder of last resort, hardly if ever grazed.

## SAMPLE SITE SELECTION

It is desirable to find a reasonable area (minimum 20m x 20m) of visually homogeneous vegetation, accessible to people wearing thigh waders. It must be possible to get the sample back to base. The idea behind the 1990 feasibility study was to sample a range of sites to indicate the between-site variability present at S'Albufera.

Seven *Phragmites* sites were sampled. Site 8 had been burnt during the previous represent early stages in regrowth after fire. By contrast Sites 2 and 7 represent "mature" *Phragmites*, unburnt for several years, with thick stems averaging more than 3m in height and 12mm in diameter. Sites 10, 3 and 4 are in an area where summer salinity may be quite high, and it is hypothesised that there may be an environmental gradient running from site 2 (favourable to growth) through 10 and 3 to site 4 (unfavourable). Environmental parameters were not measured during this feasibility study but will be measured during future studies.

Three *Cladium* sites were sampled. Site 1 had been burnt one year before sampling. Site 6 represented "mature" *Cladium*, unburnt for at least 3 years, and almost impenetrable. Site 9 was thought to represent *Cladium* growing near the limit of its salinity tolerance.

## SAMPLING METHODS

In each sample site, five quadrats (each 1.0m x 1.0m) were located at random. The quadrat frame has to be inserted between the stems of the plants to ground level and then bolted together in situ. All plant shoots are cut off, as near as possible at ground or soil level (often below water level) and are brought back to the laboratory to be sorted, measured, weighed and for subsamples to be dried. Sorting is by species, but where the *Phragmites* shoots appear to form two distinct populations, thick and thin, these are treated separately. Leaf area index (the ratio of leaf area to ground area) is measured by determining, from a subsample, the ratio of leaf biomass to total biomass. Then a sub-

Table 1

*Phragmites* biomass - April 1990

| Site   | 8    | 5      | 7       | 2       | 10     | 3       | 4    |
|--|------|--------|---------|---------|--------|---------|------|
| a-g biomass (g. dry wt m <sup>-2</sup> )           | 265  | 434    | 810     | 644     | 279    | 300     | 100  |
| <i>Phragmites</i> (g. dry wt m <sup>-2</sup> )     | 246  | 362    | 792     | 632     | 294    | 278     | 72   |
| % <i>Phragmites</i>                                | 92.8 | 83.4   | 97.8    | 98.1    | 99     | 92.7    | 72   |
| Leaf Area Index (total)                            | 1.3  | 2.4    | 1.95    | 2.6     | 1.2    | 1.4     | 0.7  |
| LAI ( <i>Phragmites</i> )                          | 1.1  | 1.1    | 1.85    | 2.3     | 1.2    | 1.2     | 0.5  |
| <i>Phragmites</i> density (stems m <sup>-2</sup> ) | 168  | 66     | 22      | 63      | 25     | 71      | 67   |
|  |      | L S    | L S     | L S     | L S    | L S     |      |
|  |      | 17 49  | 16 6    | 8 55    | 14 17  | 19 52   |      |
| Average ht (cm)                                    | —    | 213 —  | 332 171 | 331 150 | — —    | 170 —   | —    |
| Average diam. (mm)                                 | —    | 10.1 — | 12.8 5  | 16.2<5  | — —    | 7 —     | —    |
| Average dry wt (g)                                 | 1.5  | 17 1.4 | 44 4.3  | 59 2.5  | 21 0.9 | 0.7 1.7 | 1.1  |
| Moth damage  |      | 25     | 9       | 29      | —      | 25      |      |
| % large stems                                      | 0    | (May89 |         | (May 89 |        |         | c.60 |
| % all stems  |      | 0%)    |         | 67%)    |        |         |      |

(—=not recorded, a-g=above ground L=large, S=small)

Table 2

*Cladium* biomass - April 1990

| Site  | 1   | 6    | 9    |
|---|-----|------|------|
| a-g biomass (g. dry wt m <sup>-2</sup> )    | 295 | 402  | 209  |
| <i>Cladium</i> g. (dry wt m <sup>-2</sup> ) | 295 | 392  | 188  |
| % <i>Cladium</i>                            | 100 | 97.5 | 90   |
| Leaf Area Index                             | 2.7 | 4.3  | 1.74 |
| LAI ( <i>Cladium</i> )                      | 2.7 | 4.3  | 1.55 |
| Density (stems m <sup>-2</sup> )            | —   | 46   | 100  |
| Average dry wt per stem (g)                 | —   | 8.5  | 1.88 |



Paisatge de S'Albufera amb parcel·les de *Phragmites communis*, sense pastura i pasturades en segon terme. (Foto: Joan Mayol)  
The Albufera landscape with plots of *P. communis*, without grazing and with grazing.

sample of leaves, trimmed to a regular shape, are weighed and measured, using graph paper, to arrive at a figure for cm<sup>2</sup> per gram. In the case of *Phragmites* only the leaf blades were measured though for a few samples the area of green leaf sheaths was estimated separately. In the case of *Cladium* brown leaf tips and white leaf bases were ignored in estimating leaf area index.

A fairly detailed methodology sheet was produced in 1990 and will be further refined and also simplified for 1991. However detailed it is, it is still desirable for the principal scientist to be present on each sampling occasion, i.e. there remains an element of subjectivity such that comparison is more valid if the same scientist is present on each occasion.

The sampling is quite arduous; the *Phragmites* stems often exceed 4m in height, as do the flowering stems of *Cladium*. Both species may grow in water up to about 0.5m deep, or alternatively may form a floating root mat over a greater depth of water. It is

often quite difficult to penetrate the vegetation. *Cladium* can inflict quite severe injuries on the unwary.

There are two main reasons for measuring biomass as described. Sampling a variety of sites during one sampling period of, say, two weeks allows comparison between sites. Sampling at the same sites at time intervals (say 4 or 6 times/year) would allow estimation of net primary production.

## RESULTS

The 1990 results are summarised in Table 1 (*Phragmites*) and Table 2 (*Cladium*). In most sites the *Phragmites* or *Cladium* contributed more than 90% of the above-ground biomass. This may partly be a feature of site selection, but it does seem the case that the dominant species usually assumes nearly total dominance.

The intention was that this feasibility study would simply indicate fruitful lines of

Figure 1

| Sites | February | April/May | July | October |
|-------|----------|-----------|------|---------|
| a     |          | *         |      |         |
| b     |          | *         |      |         |
| c     |          | *         |      |         |
| d     | *        | *         | *    | *       |
| e     | *        | *         | *    | *       |
| f     | *        | *         | *    | *       |
| g     | *        | *         | *    | *       |
| h     |          | *         |      |         |
| i     |          | *         |      |         |
| j     |          | *         |      |         |

\* Represents one sample of five 1 m<sup>2</sup> quadrats.

enquiry to be pursued in future years, and any interpretation attached to it is very tentative. April biomass is far from the peak, but if the figures were taken as representing above-ground net primary production, they represent a range from 8.1 t ha<sup>-1</sup> yr<sup>-1</sup> to 1 t ha<sup>-1</sup> yr<sup>-1</sup>.

*Phragmites* shows a potential increase in biomass with time since burning from 265-810g m<sup>-2</sup>. Other performance parameters show a shoot density after burning of 168 small shoots m<sup>-2</sup>, average dry weight 1.5g, diameter <5mm, mainly <3mm, and no moth damage. After 2-3 years, shoot density drops to 66 m<sup>-2</sup> and becomes bimodal with large shoots having an average dry weight of 17 g, diameter 10mm and height >2m. This leads on to "mature" stands still with a bimodal distribution of shoot sizes, 8-20 large shoots m<sup>-2</sup>, with an average height of 330 cm, diameter 13-16mm and a dry weight of 40-60 g. per shoot. Moth damage occurs to at least 25% of stems.

*Cladium* appears to exhibit a smaller range of biomass than *Phragmites*. This may be because the "mature" stands do not involve the same proportion of woody supporting tissue. The leaf area indices of *Cladium* appear higher than those of *Phragmites*, but the comparison here is between the current year's leaves only in *Phragmites* and the more perennial leaves of *Cladium*. Probably the older leaves have significantly reduced photosynthetic activity.

Also with *Phragmites* only the leaf blades and not the leaf sheath were measured. Inclusion of the leaf sheath appears to add about 0.5 to the leaf area index.

## FUTURE PLANS

The 1990 feasibility study indicates that this line of research is worth pursuing further. A proposed 1991 sampling programme is indicated in Fig. 1. This is a compromise between an ideal programme and what, realistically, can be achieved. It combines extensive sampling of a wide range of variation in April/May with assessing the sequential samples will also provide an estimate of the production of inflorescences and seeds which may be significant components of the food web in the marsh. More sites than indicated will be sampled if time permits.

It will be desirable during the April/May sample to estimate standing dead material in all sites, primarily as an environmental parameter rather than as a component of the productivity estimate.

There was a very extensive fire in September 1990, affecting 50-60% of the marsh. This provides a good starting point for an annual sequence of samples. In 1991 half the sample sites will be located in the 1990 burnt area. Two weeks after the fire there was a major flood, which may have

had the effect of removing the nutrient rich ash resulting from the fire.

Future work beyond 1991 will depend on the data obtained during that year but desirable developments would include:

I) continue the same set of measurements on those sites burnt in Sept. 1990 over the following three years, 1992-4, to determine the changes with time since last burn;

II) excavate rhizome and root systems of *Phragmites* and *Cladium* the better to understand the above ground structure; attempt below-ground productivity studies;

III) use similar methodology to study the impact of grazing on *Phragmites* (*Cladium* is probably not grazed); this would allow comparison with the detailed work of Van Deursen & Drost (1990) in the Netherlands;

IV) analyse for major nutrient content of the productivity samples so as to elucidate the mineral cycles in the ecosystems as well as the energy flow.

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