# Progress Toward Management of Cabomba: Biological control and ecology

Research conducted by CSIRO Entomology

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## Executive Summary

Surveys for potential biological control agents continue in the native range of *Cabomba caroliniana*. We have identified the most promising collection sites and have re-sampled these throughout the year to ensure that we do not miss insects with differing life cycles. Through this process we have found three potential agents. We are currently studying insect life-cycles, identifying methods to rear insects under laboratory conditions, and conducting preliminary host specificity tests at a USDA-ARS lab in Buenos Aires, Argentina. Surveys in Argentina are reaching fruition and we expect to finish the surveys and begin importing insects, starting with the weevil (*Hydrotimetes natans*) into quarantine in Australia in mid-2007. If testing indicates that the weevil is sufficiently host specific, we would request permission to release, mass rear the weevils, and possibly begin making releases at cabomba infested sites in SE Queensland in the spring of 2008. This continued research depends on receiving funding from stakeholders and the federal government.

We have also begun surveying populations of four closely related cabomba species for additional biological control agents. Since there are no native or agricultural species of cabomba in Australia we may find good agents that are host specific to the cabomba genus and thus constitute low risk of off target effects. In 2005, we located three species of cabomba in Venezuela and identified a number of herbivorous insects including two weevils and one moth. Specimens are currently housed at the CSIRO Mexican Field Station and are in the process of being identified. Additional surveys are planned for Costa Rica, Mexico, and Puerto Rico. We expect these surveys will continue for an additional two years.

A number of ecological projects are in progress in Australia. Projects include (1) ongoing surveys of cabomba populations at four ponds and dams in SE Queensland, (2) experiments to determine the impact of cabomba on native plant communities, (3) experiments to determine how light intensity affects cabomba growth, (4) experiments to examine whether native herbivores prefer native plants over cabomba, (5) surveys to study effect of substrate on cabomba growth, and (6) experiments to examine the effect of desiccation on fragment survival. We have found that cabomba maintains high biomass throughout the year, which is conducive to establishment and impact of biological control agents. Light intensity and substrate seem to be major factors that influence cabomba abundance, information which may help control cabomba and reduce spread. In addition, we continue to identify and map new cabomba infestations for potential use as biological control release sites and collect baseline data to assess the future impact of agents when released. Recent maps of updated cabomba infestations indicate that the distribution of cabomba is increasing, particularly in Queensland, Victoria and New South Wales.

## I. Progress Toward Biological Control of Cabomba

### *Cabomba surveys in Argentina*

During the last year, we have re-surveyed *Cabomba* sites seven times to capture the seasonal variation in insect life cycles (Table 1). In addition, we have made three exploration trips to the north and north east. Thus far, no new *Cabomba* sites have been found in Argentina, although we have checked virtually every catchment and wetland in the country. Exceptions are (1) a few lakes in the north-western provinces of Tucuman, Salta and Jujuy, where the plant has never been cited, and (2) the inner areas of the Paraná/Uruguay that are not accessible by land. Our surveys indicate that the plant is mostly limited to the distribution depicted in former reports, in the provinces of Corrientes, Entre Ríos, and Chaco.

**Table 1. Cabomba survey trips in Argentina, Jan 2006 – Jan 2006**

| **Date** | **Survey location** |
|---|---|
| Jan 5 - 7, 2005 | Corrientes and Entre Ríos provinces |
| Feb 15 - 21 | Corrientes, Santa Fé, Chaco, Formosa and Entre Ríos provinces |
| March 11 - 14 | Misiones province |
| March 21 - 29 | Corrientes, Misiones and Entre Ríos provinces |
| Aug 29 - Sept 1 | Corrientes and Entre Ríos provinces |
| Oct 31 - Nov 3 | Corrientes and Entre Ríos provinces |
| Nov 28 - Dec 1 | Corrientes and Entre Ríos provinces |
| Jan 2 - 6, 2006 | Corrientes and Entre Ríos provinces |

Natural Enemies

*Hydrotimetes natans.* This Bagoini weevil feeds on plant tips while the larvae mine the plant stems. It develops in about 40 days in the laboratory. At high densities it can cause extensive tip damage with its adult feeding, as well as stem pruning and rotting from the larval mines. In the field, the adults are present all year round, and survive for approximately one year in the laboratory. During the mating season, which lasts from the end of December to February, the adults are found at dusk on plant flowers. During the rest of the year they remain under water. The larvae have been found in the stems from October to May, with populations peaking at the beginning of summer. This same behaviour has been observed in the laboratory in 3-litre containers, at stable ambient temperatures, suggesting it responds to photoperiod. So far *H. natans* larvae have only been found in *C. caroliniana*. A few adults (< 3%) were found on another submerged plant species, *Egeria najas*, which frequently grows intertwined with *C. caroliniana* in the field.

*Paracles sp.* The aquatic caterpillar was collected in several locations of Corrientes province. This caterpillar causes heavy defoliation on *Cabomba,* and seems to prefer the leaves near the terminal shoots. It feeds underwater, keeping air bubbles amidst the short hairs on its dorsum. Further laboratory experiments contest results reported before, and show this species can feed from instar 1 on *Egeria densa* (Hydrocharitaceae), but not on the other plants tested. We still do not know, however, if it can complete its development on this plant species.

*Paraponyx sp.* The gilled larva of this pyralid feed on the terminal shoots of *C. caroliniana*, causing a characteristic damage that stunts stem growth. The larva itself, however, is very hard to detect, although it is over 15 mm long, because of its cryptic habits. At the end of its larval stage, which lasts about 45 days, it spins an irregular 15 mm cocoon attached to the plant tips and wrapped with living leaves. In the field it is quite common during winter and spring (up to the end of November) but it has rarely been found during the summer. This may explain why we had not observed this insect before, since we have made most trips during summer and fall. This species has not been found on other plants collected together with *Cabomba*. Both lepidopteran species mentioned above are currently in the hands of taxonomists specialized in these families, but we have not yet received species identifications.

***Cabomba surveys in Venezuela***

We travelled through 3 areas of Venezuela (Lower Orinoco River and Delta, Gran Sabana, and Lago Maracaibo) and one area of Mexico (Veracruz) looking for cabomba species and associated herbivores. We located 6 populations of cabomba in Venezuela, including 3 species (*C. furcata, C. aquatica, and C. haynseii*) (Map 1, Table 2). Cabomba (*C. paleoformis*) was not found in Mexico.

When we found cabomba we first looked for herbivores *in situ* and then collected material to examine more thoroughly later. Two weevil species were found on *Cabomba furcata* (two adult individuals of a small black weevil with striations on its elytra and one adult individual of a larger grey weevil with sediment caked on its elytra and specialized ridges along the underside of its tibia) (Figures 1-4). Herbivore damage was apparent in the form of stem mining and pupal cases formed from the fusing of fruits (Figure 5). Insect larvae were associated with both types of damage. There were also pupal cocoons (on *C. haynesii* and *C. furcata*) that were within stems that had sand/sediment attached to the outside with fine hairs emerging from the sediment. These are probably made by lepidopteran larvae.

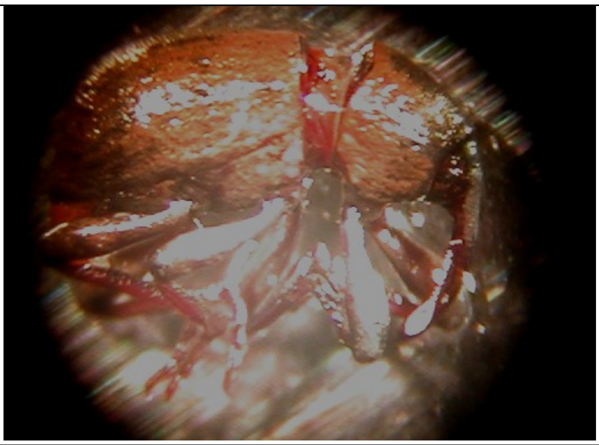
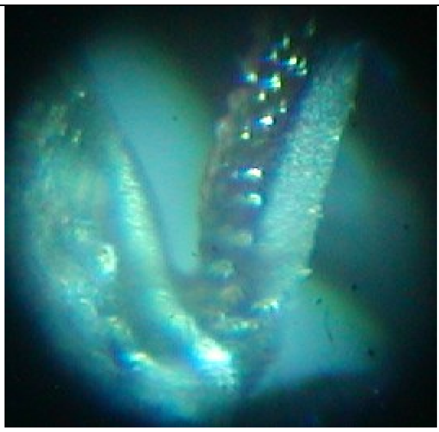
Insect and plant damage specimens were preserved in 70% EtOH and taken back to the Mexican Field Station for further examination, curation, and identification. Voucher collections of cabomba were taken from each site and are currently housed at the Mexican Field Station. Plant material was also collected in 70% EtOH for use in future genetic studies.

Researchers at the Mexican Field Station are continuing these surveys that will include all of the four additional species in the cabomba genus (*C. furcata, C. paleoformis, C. aquatica, and C. haynesii*). The surveys will include (1) searches of literature and herbarium records for information on the distribution of *Cabomba* sp., (2) surveys in tropical South America, Central America and the Caribbean for plants and herbivores, (3) preservation and species-level identification of plants and herbivores, (4) acquiring permits to transport and study live specimens in the laboratory and (5) propagation of plants and herbivores in the laboratory along with preliminary host-specificity testing.

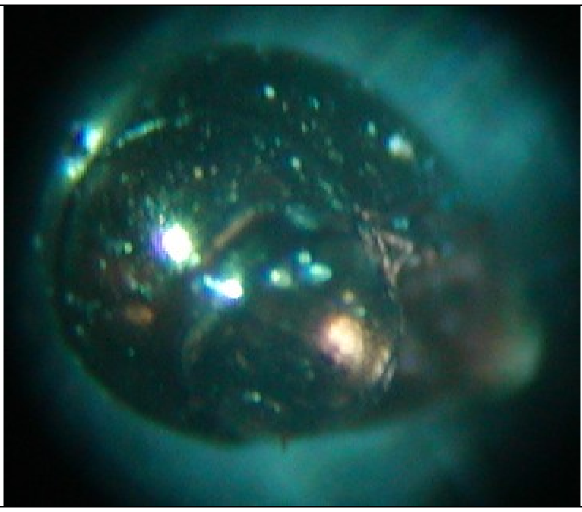
**Table 2. Locations of cabomba in Venezuela and presence of herbivores (Sept 2005)**

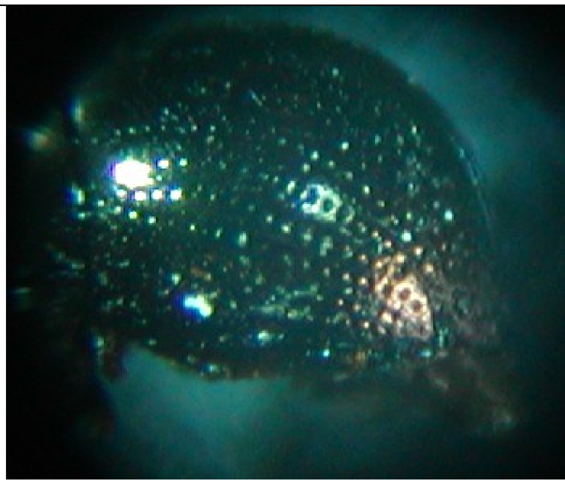
| Plant | Location | Notes | Lat | Long | Insects |
|---|---|---|---|---|---|
| *C. furcata* | Piar | pond, flowering | 7°26.778N | 63°19.872W | 2 adult weevils, flower damage, pupal cases in fruits |
| *C. furcata* | Gran Sabana 1 (C20) | river, flowering | 7°36.449N | 63°15.862W | did not sample |
| *C. furcata* | Gran Sabana 3 (C21) | pond, flowering | 7°32.549N | 63°15.862W | emergence holes of stems flower damage |
| *C. furcata* | Gran Sabana 3 (C23) | pond, flowering | 7°26.778N | 63°14.506W | emergence holes of stems flower damage |
| *C. furcata* *C. aquatica* | To Soledad | river, flowering | 8°17.336N | 63°26.504W | 1 adult weevil, multiple pupal cases in fruits |
| *C. haynseii* | El Muerto | Lagoon, not flowering | 9°17.642N | 71°45.926W | lots of stem damage, larva emerging from stem, pupal cocoons in stems (lep?) |

Map 1. Areas surveyed in Venezuela for cabomba species and associated herbivores. Red dots indicate areas were habitat was present but cabomba was absent. Green dots indicate the locations where cabomba was found.

Figures 1 and 2. An adult weevil found on *C. furcata* near Soledad. Figure 2 shows specialized ridges on tibia, possibly used for grasping slippery plant stems.





Figures 3 and 4. Another beetle found on *C. furcata* near Ciudad Piar (Morichal vegetation in the Gran Sabana)

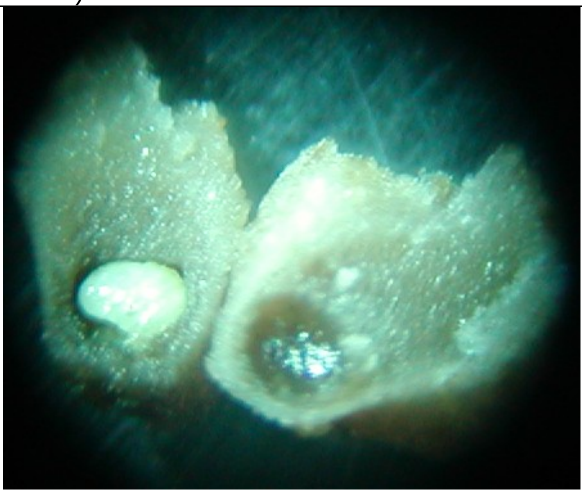


Figure 5. Larva in fused fruits of *C. furcata.*

Figure 6. Looking for herbivores on *C. furcata* in Morichal vegetation, Gran Sabana (near Ciudad Piar)

## II. Cabomba Ecology

### *Cabomba in Argentina*

A definite succession has been observed within the submerged plant community in the *Cabomba* environments sampled in the province of Corrientes. In the large lakes, such as Iberá and Santa Lucía, we have observed that the coverage of *Egeria najas*, as measured by point intercept samplings, tends to increase during the summer from almost 0% in early spring, to 20 - 40% by fall. This correlates with increasing water turbidity and temperature during the summer. Increased shade appears to benefit the shade tolerant *E. najas* plants. Likewise, the *Cabomba* stands found in more open and clear waters rarely have *E. najas* mixed with them, even during the summer.

### *Cabomba in Australia*

We continue to study the ecology of cabomba in Australia to better understand how cabomba invades and spreads and how to manage existing infestations and reduce spread to new areas. Projects include (1) ongoing surveys of cabomba populations at four ponds and dams in SE Queensland, (2) experiments to determine the impact of cabomba on native plant communities, (3) experiments to determine how light intensity affects cabomba growth, (4) experiments to examine whether native herbivores prefer native plants over cabomba, (5) effect of substrate on cabomba growth, and (6) effect of desiccation on fragment survival. In addition, we continue to validate and map new cabomba locations, take water quality data at sites with and without cabomba, take sediment samples to look for cabomba seeds, and develop research projects with interested students and research partners.

All of the surveys and experiments are still in progress. Repeated surveys at sites in SE Queensland found that cabomba biomass remains relatively stable throughout the year (Fig 7). Therefore, habitat and host plant material is available year-round for biological agents. Biomass exhibits a hump-shaped relationship with water depth where greatest biomass at 2-4 m of water (Fig 8). The site with low abundance of cabomba (MR) is a small excavated pond (approx 2 ha) with a hard clay bottom and steep sides. Nutrients and turbidity are similar between the sites and do not explain the difference. It appears that cabomba roots cannot anchor in the hard substrate (cabomba is only found in the trenches where sediment accumulates). Therefore, it is likely that the design of the pond restricts the abundance of cabomba.

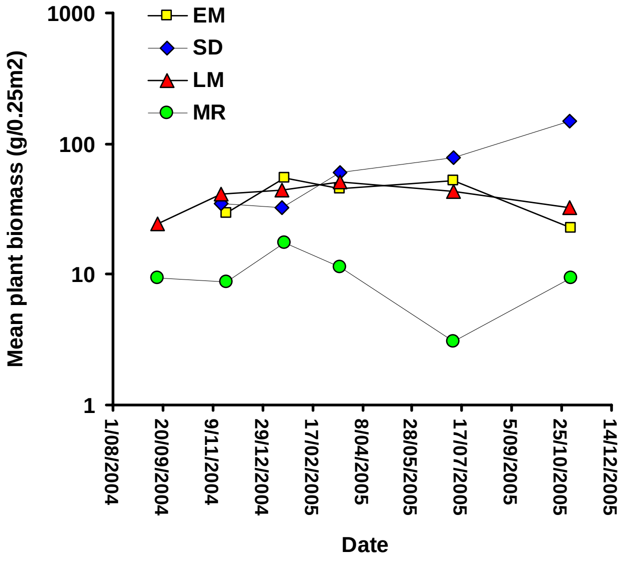



Figure 7. Biomass of cabomba remains stable throughout the year. Data are mean biomass taken from 2 and 3 m depth at each site (n=6).

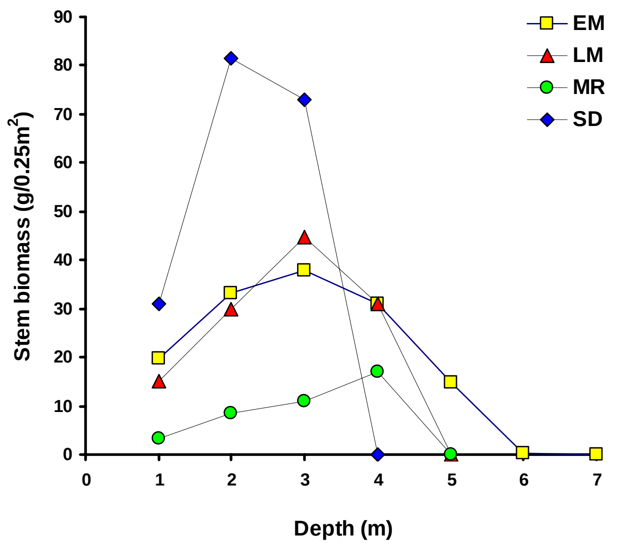



Figure 8. Biomass of cabomba peaks in 2 to 3 meters of water. Biomass is mean stem dry weight taken. Seasonal data was pooled for each site at each depth.

Observations and experiments indicate light availability is a factor that greatly influences cabomba distribution and abundance. Shade may reduce downstream spread if cabomba propagules are forced to travel down water courses covered with a dense riparian canopy. We studied how the amount of light reduction affected cabomba biomass at a dam in SE Queensland. High reduction of light (99%) eliminated cabomba with 2 months under floating shade fabric (5 x 5 m) plots. Moderate light reduction (75%) reduced biomass but did not eliminate the plant (Fig. 9). We are currently designing laboratory experiments to better predict what level of light reduction is needed to impede plant growth. We are also measuring how light availability is reduced in the water column to see if that explains the population fluctuations of cabomba at the four field sites.

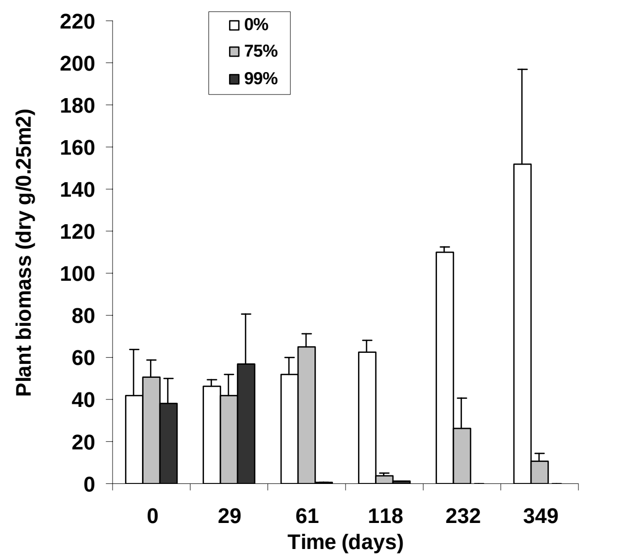
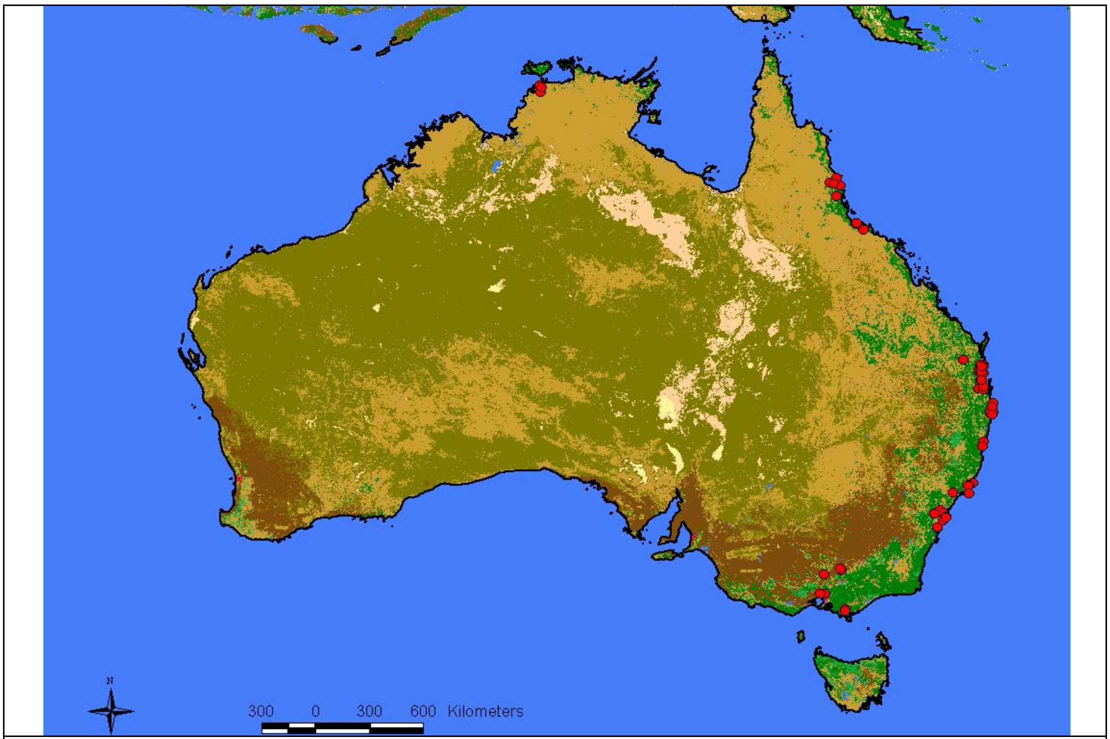



Figure 9. Shade reduces biomass at moderate levels and eliminates plants at high levels. Each treatment was replicated three times.

### *Current distribution of cabomba in Australia*

We have continued to collect data on the distribution of cabomba in Australia. Many new locations have been reported in the past year, both directly to S. Schooler and WONS Aquatic Weed coordinator Andrew Peteroeschevsky and from specimens submitted to Australian herbarium collections. This current map (Map 2) represents is the total accumulated reports of cabomba that have been verified and have associated Lat/Long coordinates. In addition to these data there are several more reported infestations that need to be verified and coordinates collected.




Map 2. Verified cabomba infestations (red dots) reported in Australia to Jan 2006. Locations are sourced from herbarium collections and locations reported to S. Schooler and the Aquatic WONS coordinator, Andrew Peteroeschevsky.