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# Herborization hot chamber set upon a steel stand: a low-cost alternative for laboratories in developing

*Estufa de herborização montada em estante de aço: uma alternativa de baixo custo para laboratórios em desenvolvimento*

Lucas Cardoso Marinho[1]; Carlos André Espolador Leitão[2,3]

[1] Universidade Estadual de Feira de Santana – UEFS, Programa de Pós-Graduação em Botânica, Feira de Santana, BA, Brasil.
[2] Universidade Estadual do Sudoeste da Bahia – UESB, Departamento de Ciências Naturais, Vitória da Conquista, BA, Brasil.
[3] Author for correspondence: caandreel@yahoo.com.br

**Abstract**
This work presents a compact herborization hot chamber, easily set up in a stand with six shelves. The heating system consists of four 100W incandescent lamps which operate at optimum temperature if you activate two lamps to a high temperature, when four lamps are on, if necessary. The hot chamber was built and tested with fine preservation of herborized plant colors if warmed by two lamps (42°C). Under maximum temperature (55.5°C), there was degradation of colors of the material although the final result was mechanically satisfactory herbarium specimens. The longest period of time required to recover the final temperature for a change of press was 17 minutes. With such results, one concludes that the hot chamber described is efficient, compact, and a fine solution for laboratories and herbariums with restricted space or small herborization demand.
**Keywords: e**quipment, herbarium, herbarium specimens.

**Resumo**
Este trabalho apresenta uma estufa de herborização compacta, facilmente montada em uma estante de aço de seis prateleiras. O sistema de aquecimento consiste em 4 lâmpadas incandescentes de 100 W, que trabalha em temperatura ótima com o acionamento de duas lâmpadas e em temperatura elevada com 4 lâmpadas acesas, quando for necessário. A estufa foi construída e testada com ótima preservação de cores das exsicatas quando aquecidas por 2 lâmpadas (42ºC). Em temperatura máxima (55,5ºC), houve degradação das cores do material, embora resultando em exsicatas mecanicamente satisfatórias. O maior tempo de retomada da temperatura final, para as trocas de prensa foi de 17 minutos. Com estes resultados, conclui-se que a estufa aqui desenvolvida é eficiente, compacta, sendo uma ótima solução para laboratórios e herbários com espaço restrito ou de pequena demanda de herborização.
**Palavras-chave:** equipamento, herbário, exsicatas.

## INTRODUCION

The drying up of botanical material is extremely important for the inclusion of the plant in a herbarium collection. It is a usual procedure for several botanical works, especially floristic. Drying processes are based on the pressing of materials and withdrawal of humidity by raising the temperature (Dombrowski, 1981), and may be carried out in different ways, from natural drying in the sun to artificial drying, with the utilization of herborization hot chambers (Castro et al., 2006). They consist of a box lodging presses containing plant samples, above a heat source. It is advisable to maintain the temperature below 45°C, because excessive heat may cause loss of information, such as aroma and colors (Judd et al., 2009). Thus, the gradual drying up with incandescent lamps, with good air circulation, maintains the original colors and texture of the sample (Mori et al., 1989).

Herborization hot chambers are often a handicraft work and there very few literature works of medium to large circulation, describing projects, fail to describe their performance.

The lack of physical space is a reality in many research and educational organizations and herborization hot chambers are bulky equipment which may be difficult to lodge in small laboratories and herbariums or places which do not need a large herborization hot chamber. With simple, creative initiatives one may find a way to solve problems of lack of space or funds, by developing alternative techniques (Paiva et al., 2006) and compact and inexpensive equipment, as efficient as

manufactured ones (Leitão & Cortelazzo, 2008).

The present work is meant to offer a solution for laboratories and herbariums which have the above-mentioned problems, by developing an efficient herborization hot chamber set up in a steel rack. Our purpose was to set up a inexpensive hot chamber, easy to construct, which could work in an ideal temperature for a fine herborization, with the option of also working at a higher temperature for events of great demand, performing due tests of the project, as well as analyzing the efficiency of the herborization process.

## MATERIALS AND METHODS

***Setting up the hot chamber:*** The herborization hot chamber is easy to set up in a 198cm high steel rack, containing 6 shelves (91cm wide and 30cm deep). The measurements set forth herein refer to the rack utilized in the present work, which may undergo small changes if a slightly different stand is used, when setting up the hot chamber. It was necessary to remove two shelves in order to fit the hot chamber. The hot chamber is supported by the lowest shelf of the rack and it bottom is a rectangular piece of plywood (bottom plywood) with the size of the shelf. The hot chamber is 81cm high, has an upper door for general use and a front door used to organize, clean and maintain the hot chamber (Figs. 1A, B, 2A). The material utilized to construct the hot chamber is listed in Table 1.

**Table 1.** List of materials utilized to build the herborization hot chamber.

| Description of the material | Unit | Quantity |
|---|---|---|
| **Wood** | | |
| 10 mm thick plywood | m² | one sheet 1.60x2.20 m |
| Wood for the baseboard (91x7x2) | cm | 91 |
| Batten | m | 4 |
| **Hardware** | | |
| Head nails for the batten (15x15 or 1.1/4x13) | g | 200 |
| Drawing pins | Units | 150 |
| Chain | m | 1,3 |
| 1/4” x 7.8” screws, with cleft head, machine threaded, with nut and washer | Units | 22 |
| 1/4” x 1.1/4” screws, with cleft head, machine threaded, with nut and two washers | Units | 4 |
| Window hinges with screws | Units | 4 |
| Small flat latches with screws | Units | 2 |
| Small cylindrical latches with screws | Units | 3 |
| **Electric System** | | |
| Threaded china sockets for incandescent lamps with respective fixating screws | Units | 4 |
| 100 watt incandescent lamps (or 200 watt halogen lamps) | Units | 4 (6) |
| Two-section switches | Units | 1 |
| 2 x 3.5 $mm^2$ parallel wire, 300V | m | 5 |
| Electric plug (male) | Units | 1 |
| Tight-wire | Box with 50 units | 1 |
| **Other parts** | | |
| Carpet pieces (90 x 10 cm strips) | Units | 5 |
| Leather pieces (6 x 6 cm squares) | Units | 2 |
| Shoemaker’s glue | ml | 150 |
| Insulating tape | Small roll | 1 |

The back (back plywood) and each side (side plywoods) of the hot chamber were made from a single plywood sheet 10mm thick, and measured 91 x 81cm and 81 x 30.5cm respectively – The lower part of the front of the hot chamber was made from a piece of plywood (the front lid of the light box) of 91 x 13cm$^2$; a piece of baseboard (the front door support) to hold the front door hinges, the latter also made of plywood, measuring 92 x 61 cm$^2$ (Fig. 1A, B).

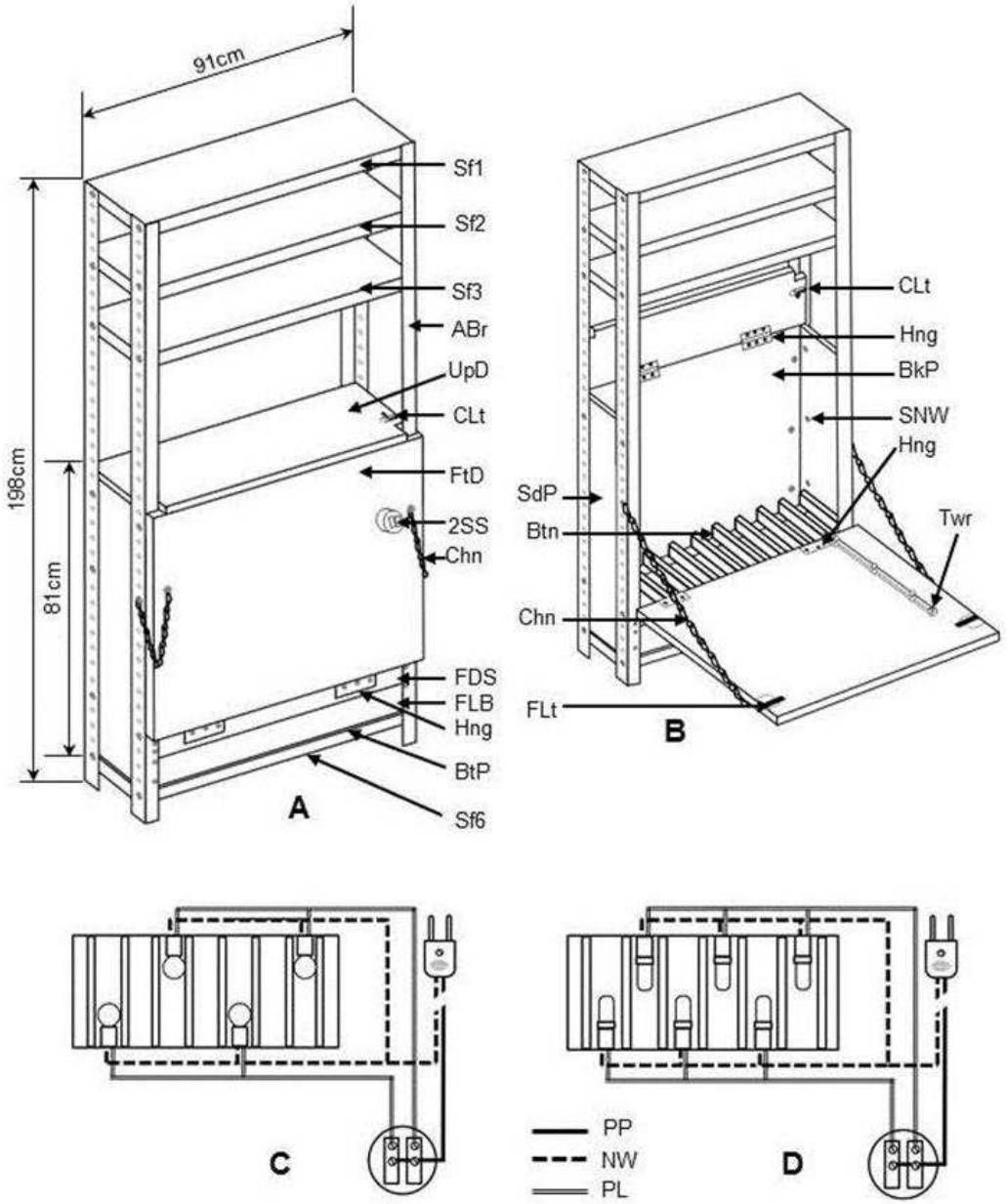


**Figure 1.** Drafts of the herborization hot chamber. A – General aspect of the hot chamber set up upon a rack, with the front door closed. B – As in A, with the front door open. C – Draft of the electric wiring of the herborization chamber, using incandescent lamps as a heat source. D - Like D, but using dichroic halogen lamps. Legends: 2SS- two-section switch; ABr- angle bar; BkP- back plywood; Btn- batten; BtP- bottom plywood; Chn- chain; CLt- cylindrical latch; FDS- Front door support; FLB- front lid of the light box; FLt- flat latch; FtD- frontal door; Hng- hinge; NW- neutral wire; PL- phase wire to lamps; PP- phase wire from plug; SdP- side plywood; Sf- shelf; SNW- screw with nut and washer; Twr- tight-wire; UpD- up door.

All these pieces were attached directly to the rack structure with 1/4" x 7/8" screws (Fig. 2B) which are the same original screws used to fix the shelves, or 1/4" x 1.14" ones in the case of the support of the front door, which are longer, because the baseboard wood is thicker (Fig. 2C). The pieces were screwed up in the holes of the steel angles. As the rack used had holes in only one face of the angle bar, on the side of the rack, additional holes were made on the face that had no holes, in order to screw up the back plywood, the front lid of the light box and the front door support (Fig. 2C). Only the bottom plywood was fixed with nails, and it was attached to the side plywood pieces, the back plywood and the front lid of the light box, with 15x15 or 1.1/4 x 13 nails.

The upper door was attached to the back plywood by two window hinges attached to the internal surface of both pieces (Fig. 2D). The hinges of the front door were attached to the internal surface thereof and to the external face of the front door support (Fig. 2C, F). Two 65cm chains were attached to the sides of the front door and the structure of the rack, in order to hold the front door, when open at 90°C (Figs. 1B, 2F). All the pieces of plywood were attached, internally, to the angle bars (Fig. 2B, C, H). The upper door presents cutouts on the sides opposite the hinges, in order to fit upon the front door, when closed (Figs. 1A, 2D, E). The front door rests externally upon the rack structure (Fig. 2C, E).

In order to support the presses, eight 27cm long pieces of batten were placed with the widest part in a vertical position. They were nailed to the bottom plywood, supported by a horizontal batten also firmly attached to it, and to the front door support, with 15 x 15 or 1.1/4 x 13 batten nails (Figs. 1B, 2F, G).

Two pairs of china sockets for lamps were attached to the internal face of the light box lid and to the back plywood respectively, positioned as shown in Figures 1C, 2F and 2G. The electric wiring of the sockets was made parallel, and each pair is activated by one of the sections of the switch (Figs. 1C, 2G, H, I). The two-section switch was mounted externally on the front door of the hot chamber (Figs. 1A, 2I), but the wiring runs inside it, and gets to the switch through a hole (Figs. 1B, 2H). The feeding of the hot chamber is done by a 2 x 3.5 $mm^2$, 300V parallel wire connected to a male plug. Wire joints were duly insulated with insulating tape (Fig. 2H) and internal wires were fixed to the plywood sheets by tight-wire (Figs. 1B, 2G, H). Four 100W incandescent lamps were used as sources of heat (Figs. 1C, 2F, G), activated in pairs by the two-section switch (Figs. 1C, 2I). In the Brazil, according to the Interministerial Ordinance (Portaria Interministerial) No. 1007/2010, 100 W incandescent lamps are no longer manufactured since June 2014. The ones with up to 60 W will be sold until June 2016 (Brasil, 2010).

The dichroic halogen lamps are an alternative to the use of the equipment here proposed, since they also produce heat, with the advantage of being more compact (Felicíssimo, 2003; Paiva, 2014). In this case, each pair 100 W incandescent lamps should be replaced by three 200 W halogen lamps, and the number of pieces of batten must be reduced to seven, in order to obtain the correct arrangement thereof in relation to the halogen lamps (Fig. 1D).

Two simple flat latches were used in the internal part of the front door, which, when closed, is locked by the latches at the front angle bars of the rack. To make it easier to close the latch with the door closed, the tip of the latch bolt was slightly curved upward (Figs. 1B, 2K). The upper door has two cylindrical latches on the outer part, which serve to keep the door tightly closed, by holding it by the holes of its own lateral angle bars of the rack. In order to adjust the height of the latch to the hole, a piece of leather, cut in the shape of the latch, was utilized (Fig. 2E). A third latch was placed inside such door to keep it latched in open position, also directly attached to a hole in one of the rack angle bars (Figs. 1B, 2D).

In order to stanch the hot chamber, pieces of carpet were used in the line of contact between the fixed parts and the doors, to seal

them when closed (Fig. 2D, J). To fix such carpet pieces, shoemaker's glue was used (Fig. 2D, J) and, in the case of stanching joints, drawing pins were placed on the borders upon their gluing, for an extra reinforcement (Fig. 2L, M).

***Testing the equipment:*** Samples of fertile branches of *Lantana camara* L. (Verbenaceae) and *Opuntia cochenillifera* (L.) Mill. (Cactaceae) were chosen to test the efficiency of the hot chamber in practical use, as well as to compare the herborization speed and the quality of herborized samples under the two conditions provided by the hot chamber.

The time necessary to reach the maximum temperature (with two pairs of lamps turned on), going from the maximum temperature with a pair of lamps turned on, was tested.

The recovery of the final temperature of the hot chamber upon the opening of the upper lid for 15 seconds (time required to change the press) and also upon the full opening of the hot chamber for 20 seconds (time required to change a voluminous press) was also tested.

At all stages of the tests, three repetitions were made. Temperature measurements were made with a thermometer with the bulb positioned near the internal surface of the upper door and also near the press support railing.

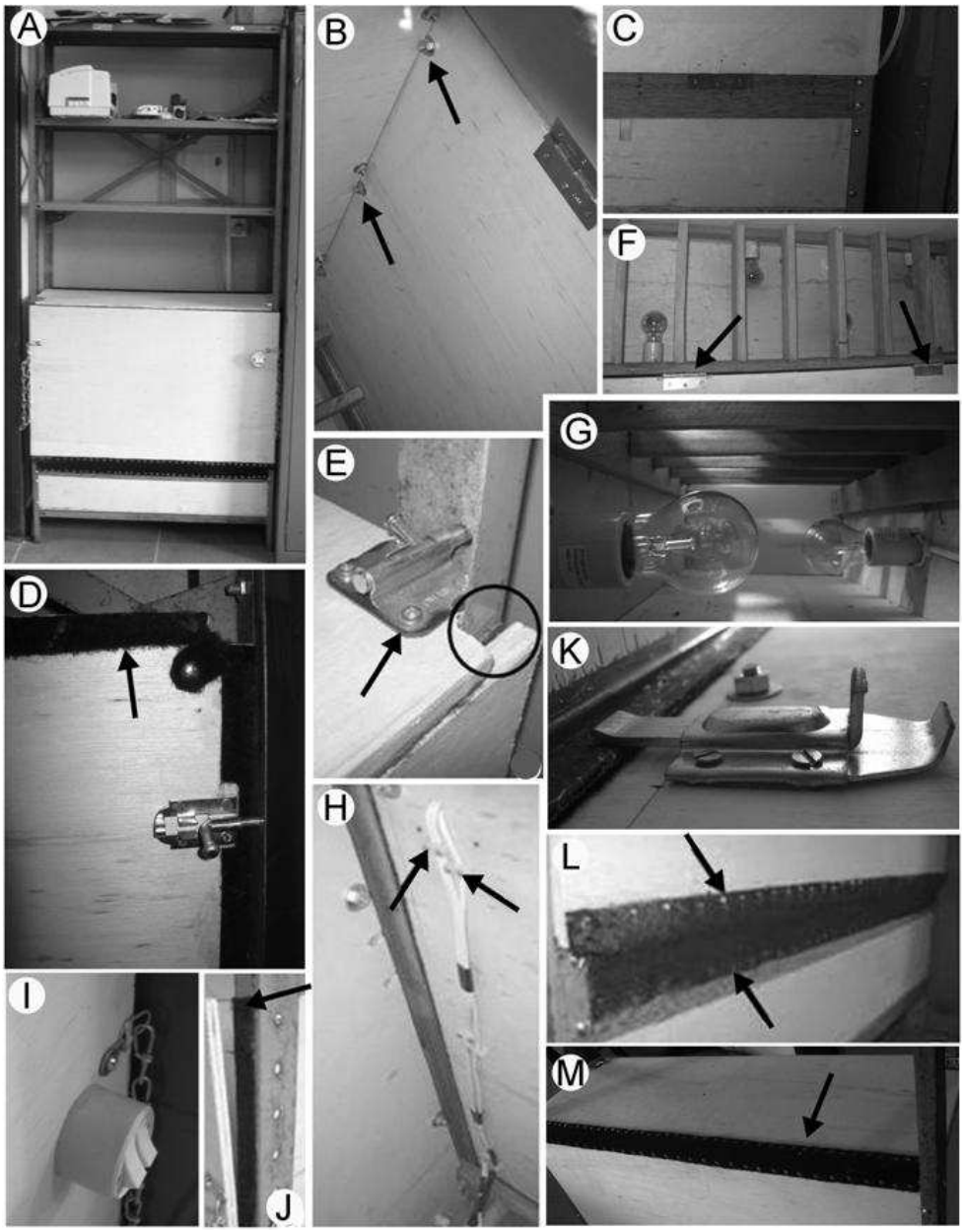


**Figure 2.** Photographs of the herborization chamber. A – General aspect of the hot chamber set up in a rack. B – View of the interior of the hot chamber with the upper door open, showing the screws that fix the sheets of plywood on the rack (arrows). C – Detail of the outside of the lower front part of the hot chamber. D – Detail showing the upper door open, the inner latch of the door, one of the hinges and stanching carpets (arrow). E – Detail showing the external cylindrical latch of the upper door, closed, attached to an angle bar hole. The cutout in the upper door can also be seen (circle) as well as the piece of leather under the latch (arrow). F – Upper view of the battens upon the light box, also showing the hinges of the front door (arrows). G – Internal view of the light box with above-mentioned battens. H – Internal view of the front door with the wires that go to the switch, along the inner side of the door, showing the tight-wires (arrows). I – Detail of the two-key switch on the external part of the front door. J – Detail of the stanching carpet glued to the angle bar (arrow), which seals the contact between the angle and the front door, when closed. K – Detail of the flat latch attached to the inside of the front door, with the pawl twisted up (arrow) to make easier the closing thereof against the angle bar. L – As in C, but upon the stanching of the joint between the front door and the support of the front door. The photo shows the drawing pins (arrows) on the carpet borders. M – Detail of the joint between the upper door and the plywood of the bottom stanched with carpet, with drawing pins (arrows) on the edges if the carpet.

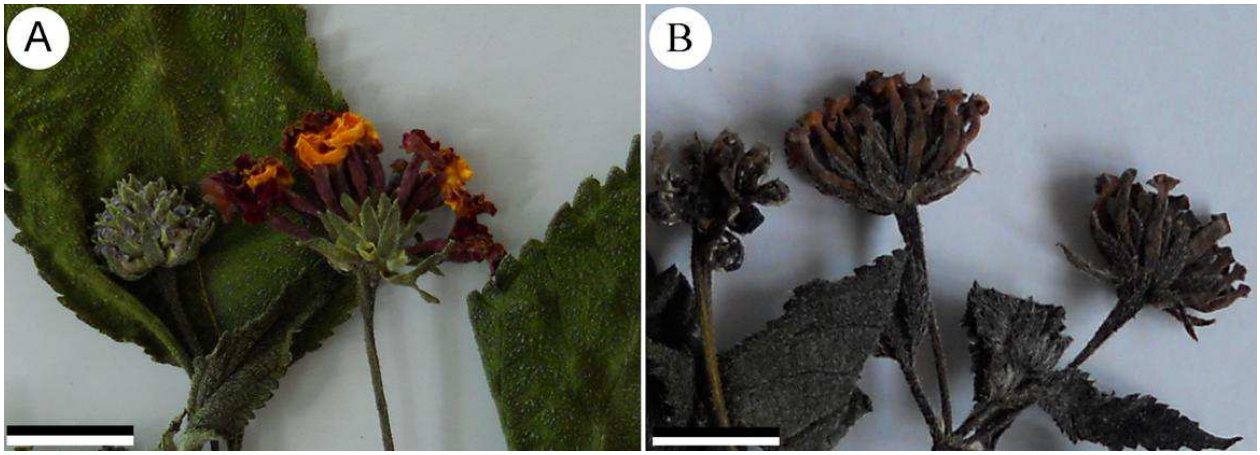


**Figure 3.** Fertile branches of *Lantana camara*, herborized by a pair of lamps (A) and by two pairs of lamps (B). A – General aspect of the duly herborized branch. Although it is a black and white photo, one notices the various shades of the flowers. B – General aspect of the branch herborized at a higher temperature. One sees the flowers have a dark homogeneous shade (Scale: 1 cm).

## RESULTS AND DISCUSSION

The maximum temperature reached by a pair of lamps was 42°C, immediately below the upper lid, which temperature is a little below the maximum temperature suggested (45°C) by Judd et al. (2009). Near the lamps the temperature reached 54°C (above the railing). With two pairs of lamps, the temperature reaches 55.5°C and 72°C, respectively.

The change of material test, in the first situation (one pair of lamps), showed a reduction of temperature from 42°C to 38°C, upon opening only the upper door. With complete opening of the hot chamber, i.e., the opening of both doors, the temperature went down to 32.5°C, returning to 42°C two and a half minutes afterwards.

In the test with two pairs of lamps, the exchange of material with only the upper door open, led to a reduction of temperature from 72° to 52°C, and, with the hot chamber completely open, the temperature went down to 49°C, with temperature recovery within two and a half minutes.

With the hot chamber completely heated up with a pair of lamps, an average of 17 minutes were spent in order to reach the maximum temperature.

The *Lantana camara* samples, under the heat of a pair of lamps, were completely dried up within 24 hours (Fig. 3A), whereas *Opuntia cochenillifera*, a succulent species with aerial branches and floral receptacle modified as cladodes, took approximately 72 hours to attain the characteristics of a herborized plant. Under two pairs of lamps, *L. camara* was completely herborized in 20 hours (Fig. 3B) and *O. cochenillifera* in 60 hours.

The material herborized with a pair of lamps presented, in all repetitions, the best conservation of its natural color, especially the fertile parts, both in *L. camara* (Fig. 3A) and in *O. cochenillifera*, whereas, those herborized under maximum power became darker. On the other hand, the resistance of preparations seemed similar under both heat conditions. Such results demonstrate the efficiency of the herborization hot chamber, which presented fine results under lower temperature, corroborating the information provided by Judd et al. (2009). These authors also pointed out the risk of a fire in temperatures above 45°C, therefore, we do not recommend the use of the maximum power of the hot chamber described herein, unless there is a responsible person nearby. However, the hot chamber we tested remained active, at its maximum power, day and night, and there were no indications of overheating or any sign of danger of a fire. One must also pay attention to the fact that press chains or any other flammable part, conducive or rigid does not touch the lamps. It is advisable to have the electric wiring revised from time to time, in order to use the hot chamber safely.

Lamps with a lower power (eg. 60 W) can also be used, however, will have less heat and thus would require a longer time to complete herborization material.

Although no tests have been conducted using dichroic halogen lamps, it is known that this type of lamp generates equivalent to one third of the heat generated by an incandescent lamp of the same wattage (Felicíssimo, 2003). Once the tests performed in this study showed that a pair of 100 W incandescent lamps raises the temperature to 42ºC within the hot chamber three 200 W halogen lamps would be required to generate the same amount of heat.

At maximum temperature, the herborization process was fast, and good preparations were obtained, notwithstanding the fading of colors. Therefore, one may conclude that maximum power should be avoided, when the hot chamber is not in high demand.

In view of its versatility, efficiency, compact size, harmonious aspect with the working place and low construction cost, the hot chamber herein described is recommended for compact laboratories and herbariums or places where herbarium specimens are not in great demand.

## ACKNOWLEDGEMENTS

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