Medical Brooders for Aviculture

(Proper Design and Function Principles)

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This project was initiated to establish an artificial support system for altricial chicks short of weaning as well as those individual birds rendered incapable of survival or recovery due to a compromised metabolism or an inherent or acquired lack of proper thermoregulation. The goals were to create an enclosed environment with maximum efficiency for heat and humidity retention/control. Those factors that necessarily had to be considered prior to this project were:

- maximum patient safety including use of non-toxic, non-abrasive materials
- fail safe thermal control
- patient isolation from additional pathogen exposure
- minimal patient stress due to environmental influence
- good visualization of patient by staff and clinician for rapid assessment
- light weight materials for ease of transport by staff personnel of variable physical strengths
- reliable, simple electronics
- one hundred percent disinfectability
- reasonable cost investment
- long life expectancy
- low maintenance schedule

The motivation to pursue brooder thermodynamic field studies, if one considers the range of features in a brooder versus the range of costs attached to them, was because the ideal unit for avian patients does not commercially exist today. Factors such as low weight, maximum efficiency, reasonable cost investment, patient safety and simple electronic componentry are unfortunately diametrical in opposition to each other given current technology and materials that are available. For instance, greater heat efficiency and safety are often synonymous with additional backup systems and increasingly greater costs. A highly sensitive digital thermal control/display unit with solid state electronics having a constant control of 0.05°F tolerance or less will have a cost of over $300 each. An ether filled metal wafer disc with thermomechanical control has a +1 to 2°F variance and a six month maximum accurate life expectancy with a cost of approximately $15. A compromise must be drawn between them. This is the case in every aspect of design and construction. Perfection is not possible. Because total brooder function is massively expensive, cost efficiency should be placed high on the overall priority list secondary only to successful patient recovery. Purchase costs cannot be ignored in the high overhead business of raising and treating psittacine babies.

The primary goal of this project, first conceived in 1987, was to design and produce a limited number of brooders for clinic use to explore what limits of patient rates for improvement and recovery might be expanded.

Experiences with older surplus human preemie and pediatric chambers and several commercially available avian brooders were unsatisfactory, due either to thermal/mechanical unreliability (i.e., burned out lightbulbs, excessive dehydration, poor insulation quality, etc.), materials failure ("macaw destruction syndrome") or inability to achieve complete disinfection due to organic debris retention in metal screens, corners, hinges, etc. In addition, the use of asbestos insulation and lightbulb based heater components, such as found in the Armstrong™ type glass and metal units, makes these brooders totally unacceptable. The risk to both human and infant bird life does not justify their easy availability or convenience under any circumstance.

The following is a review of our experiences of the design and construction of ten custom brooder prototype units and an evaluation of four years continuous use at the California Exotics Clinic.

It is fundamentally important for avian clinicians and aviculturists involved in domestic propagation to understand the basic thermodynamics of a working brooder in order to be able to deliver maximum care benefits to baby birds. Proper environmental control is secondary only to proper body fluid balance and nutritional support for growing and recovering chicks. An improper brooder environment will directly and adversely affect the parameters of the first two categories if not recognized. Cold chicks do not demonstrate proper intestinal passage rates and require additional calorie support to grow and survive. Dehydrated patients do not possess proper fluid compartmentalization in their tissues and do not efficiently process pharmaceutical agents in the intended pathways. The end result is a waste of effort, time, money and babies that contribute no benefits to aviculture or the individual raising them.

This is a fundamental form of preventive medicine and the employment of proper environments will eliminate the unnecessary pharmaceuticals that are all too frequently relied upon to correct pathophysiological conditions diagnosed in intensive care birds both at home and during hospitalization. The initial cost of a good brooder will repay itself if it only saves one macaw or Amazon one time. The question of what is a good brooder is discussed in detail below.

In order to understand the internal environment of an avian brooder, it is important to understand thermal environment on a conceptual level. It is perhaps easiest to visualize as being comparable to the earth's atmosphere, as represented by a color coded computerized model with the various wind patterns, thermal upwellings, weather fronts and relative cooling and heating regions with their high and low pressure systems. This mental picture is familiar to us all on the daily weather reports. The same phenomena take place on a much smaller scale within a building, and, in turn, within each individual room of that building on an ever increasingly more subtle and delicate level. It is critical that the nurseryman understand that rooms (including hatching and nursery rooms) possess micro climates, with temperatures varying as much as 20°F to 40°F from corner to corner, as well as similar variances in humidity. The same areas of a room can vary by one to double digit degrees from night to day. This is mostly dependent on the outside air temperature and ongoing climatic conditions (i.e. rainstorms, seasonal changes, etc.) , but also on building materials, room air flow and appliance presence (refrigerators, humidifiers, etc.) which produce heat (motors) and cold (air conditioning) which effect the overall room conditions from outside the chick's living quarters.

Micro Environment Control

Medical brooders contain a micro environment that is similar in nature to room environments and is also effected by the immediate surrounding external conditions. The degree to how drastically the surrounding room and building environment effects the internal brooder environment depends on their relative volumes of air. The greater the relative volume of the surrounding environment, the greater the influence will be on the air inside the brooder. In an attempt to minimize this uncontrollable influence, the design must incorporate efficient insulation, either in the form of a wall that has a good insulation capacity or as an insulation blanket applied to the wall surface after construction is complete.

Those elements that will assist insulation in maintaining stable temperatures are:

- active heat production devices (heaters)
- heat sinks (heat retaining devices)
- internal reflectors (shiny surface).

The elements that serve to defeat insulation are:

- defects in materials (i.e., thin plastic or glass)
- internal air retention defects (leaks in the walls)
- ventilation (drafts from excessively large air holes for oxygen)

Since it is necessary to incorporate several of these elements simultaneously in the same brooder, primarily heaters, chamber wall materials of various insulation coefficients and active ventilation, a balance must be achieved between them to maximize each in relation to the needs of the patient. The remaining factors may be used to increase brooder efficiency when needed in order to restore this balance when perfect temperature control cannot be achieved without their use. The perfect brooder would be capable of retaining very small amounts of heat for extremely large periods of time without over heating the patient (or chick) and still have a constant flow of fresh air entering the chamber and waste carbon dioxide leaving the chamber at exactly the same rate. In addition to this delicate balance, it is ideal to have the brooder be light weight, have clear front windows, easily manufactured, have few moving parts and cost as little as possible.

One of the greatest lessons that we learned was that ventilation is given far too much priority in relation to the actual patient requirements. The air volume of most brooders large enough to accommodate the average psittacine patient contains sufficient oxygen to support the patient for several hours without any ventilation at all. The fully inflated volume of the lungs needed to support life is the bottom line value for minute to minute brooder ventilation and this can be achieved with even an extremely small cross sectional opening in comparison to the general perception of bird breeders and brooder designers. It is helpful to imagine the brooder as being a pond, with the ventilation port as the incoming stream and the lungs as the dam gate regulating the water being used. It is only necessary to fill the reservoir with oxygen as fast as it is being used up. Since the respiratory capacity and oxygen uptake demands will vary from patient to patient, it is essential that some flexibility exists in the original design and, therefore, ventilation port controls for opening up or closing down the air hole size are desirable. The greatest problem that arises from a practical standpoint is that as the forced air intake becomes strong enough, the outflow of chamber air is also increased. Since the relatively cooler external air is sinking to the floor of the brooder and the more desirable preheated air is being elevated and lost through exhaust ports, hinge areas, hardware sites and lid seals, this becomes important as well. This phenomena has an exponential effect on internal temperature control when the air input port is coupled with a fan to create a moving air environment. Consider the huge increase in water pressure and its effect on the dam when the flood gates on a reservoir are opened to full flow in the earlier "water flow" comparison model.

Mixed air environments are more desirable for good chick performance than still air brooders, as moisture build-up is properly eliminated and temperature gradients do not form from top to bottom. The temptation is to build in a strong, reliable motor fan for the chamber. However, the increasing new air flow introduction directly counter effects the benefits of heat control and insulation. It is, therefore, ideal to strive for a brooder fan that mixes the air at a rate just slightly greater than normal convection currents inside a still air brooder. More power is not always better. When the air flow is too great, the demand for superior and more costly insulation and heat retention devices, such as heat sinks, rises dramatically. We actually found that the air inlet ports on the blower unit needed to be recut and drastically reduced from eight, one-half inch holes to three, quarter-inch holes in our largest unit or the desired temperature of 85 to 90°F and 60% humidity could not physically be maintained under normal room conditions when a 32 cubic foot/min (CFM) fan was installed due to the excessive air flow into the unit. The exit ports were entirely sufficient to sustain a proper oxygen, heat and humidity levels by themselves for short periods of time without opening any of the air intake valves. Very small factors become critically important as one seeks to exert ultimate control over a finite volume of space (i.e, heated air in a sealed chamber).

Humidity has been well demonstrated to be a crucial factor in proper patient recovery and disease prevention. The higher the temperature and the greater the air exchange, the greater the rate of patient body water loss through skin evaporation and normal respiration. It is important to provide a humidity source that is both constant and safe for the birds in the brooder. Water cups placed on the floor can be used, but also represent an unacceptable danger to infants or weakened individuals that may drown or act as potentially contaminated drinking water due to feces, dunked food or body discharges. Many climates, such as our native southern California, have relatively low levels of humidity and it is essentially impossible to elevate internal humidity levels without crowding the patient when only using floor cups and effective ventilation is present.

Experience has led us to prefer an elevated, built-in container with a variable water surface area design. Wet sponges in holding trays can also be used due to their tremendous surface area and constant evaporation rate, but sanitation control and fungal spore production is a concern when dealing with compromised patients or chicks and cross contamination can occur between rapidly rotating hospital cases. Multi-sectioned water trays with graduated walls seem to work the most efficiently for both space conservation and varying humidity demands under different conditions. Triangular configurations or multi-sectional rectangular troughs have both been used. These are attached on the upper walls of the chamber to maximize floor space and to prevent patient drowning. The trough floors are angled such that the water depth is lower at one end, further enhancing water surface variability. The deeper the water, the greater the surface area of water is exposed to moving air in the brooder for higher humidity production. The triangular troughs tend to be more difficult to clean. NolvasanTM or some other nonfuming, nonirritating disinfectant will greatly assist in reducing fungal and bacterial problems in warm water uses. It would be ideal to place the water source directly into the air flow if the brooder design will allow for this in order to maximize humidity production. I recommend that 55% to 70% relative humidity be utilized to prevent dehydration.

Many rain forest species live in an 85% humidity environment, but this level is very difficult to achieve in arid climates. Some marine or tropical avicultural locations may have a problem with excessive humidity, unless the building is insulated, and must be actually supplied with a room dehumidifier. In these cases, warmed, forced room air will assist to reduce humidity levels. An accurate hygrometer is fundamental and can be purchased as part of a thermometer/hygrometer unit for about $15.00 at Radio Shack. These units are positioned inside the front panel for easy viewing and away from curious beaks, tucked inside a shielded retainer slot. Again, relative brooder humidity, like temperature, is predominantly controlled by the external room environment. Electronic humidifiers have been successfully employed to adjust the level of room air humidity entering the chamber to the desired degree. This concept may be economically advantageous if a large number of brooders are to be used, both from a purchase as well as a maintenance standpoint and is the current trend for breeders with large nurseries.

Stress Reduction

One of the initial factors that prompted us to consider a new brooder design was the fact that many of the larger patient species, such as macaws, were severely curtailed in their movements in the older human pediatric "preemie" chambers and all commercially available baby bird brooders. Since a significant percentage of our patients are wild breeders, this situation would become increasingly more stressful as the patient's strength and mental awareness improved with therapy. Stress reduction has become a focal point in our client education efforts in promoting improved chick production and for preventive medicine. Yet we were one of the greatest offenders of our own guidelines on this point prior to the project. It became paramount that we address the patient's need for space, security and free movement to promote rapid healing as well as to gain valid observations of the treatment response. We questioned what increase in recovery rate we could promote if a brooder could be designed to provide separate perching, movement and feeding areas for these breeders in the clinic. Considering that a Hyacinth or Green-wing Macaw could easily occupy three square feet resting, plus room for tail turning, this could entail quite a space! We decided on two models, the smaller one being approximately four cubic feet for small psittacines (up to small Amazon size) and the other being 24 cubic feet for large psittacines and other zoological species.

In order to promote psychological security, all brooder walls and the top were constructed of an opaque plexiglass and a clear plexiglass panel was used for the front wall as a window. This lack of visibility prevents patients from feeling threatened by other birds, movement or staff members in the room, but allows for rapid patient assessment.

The floors are constructed of the same plexiglass, but each unit has a powder coated aluminum plate which slides in through a track at one end and acts as a heat sink. This aluminum plate is light weight, resists scratching and is nontoxic. It serves to absorb and trap heat under the newspaper substrate. The plate acts as a heat bank and provides heat by direct conduction to the patient's feet as when a chilled bird is placed into the preheated chamber. This is much more efficient than strictly warming birds by air conduction alone, as the large vein system that is present in the feet of birds carries the heat to the chilled body core more quickly. It also acts to provide heat to the chamber air by convection once the lid has been opened for feeding or cleaning. We have found that the delay for chamber air reheating can be reduced from approximately ten minutes per episode with the old Armstrong™ chambers to approximately one minute or less with this device. The temperature will remain stable for patients' comfort up to 30 minutes after the unit is turned off, even with the lid open under moderate room conditions, as long as the patient's feet remain in contact with the heat sink plate.

Since critical patients may simultaneously require both frequent handling and/or drug administration, as well as constant heat support, this heat sink eliminates a serious physiological stress unavoidable with conventional brooders. We found that this approach was so efficient that we could entirely eliminate the external filling ports for the water trays that we initially installed to avoid the problem of patient chilling each time the lid was opened. It is important to remember that aluminum expands with heat and that the holding track not be too snug to avoid cracking the plexiglass box, but not too generous either, as drafts will then be created if the holes left on the sides of the plate let air leak in.

The thickness of the plexiglass wall and top material should also be considered when designing a brooder unit. Plexiglass is not the only material available, but does have the advantages of being readily available in both colored and transparent sheets, is a fairly good insulator once a certain thickness is achieved, is water proof, seals well with special glues, is light weight and, if the appropriate cutting tools are used, lends itself to conventional construction techniques. There is a trade-off between insulation quality in the thicker sheets and the inherent weight and cost increases that accompany them. High grade (generally American produced) materials are higher priced, but clearer and more scratch resistant than overseas grades. Heavy gauge plexiglass is not cheap and must be purchased in 4' x 8' sheets. We have found that 3/8" (or heavier) plexiglass is probably a good trade off between cost and insulation quality.

All accessories, including the monitoring instruments, heat sink, perches, heater fan and food cups, are completely removable so that the entire chamber can be completely submersed by itself for disinfection purposes. The walls and surfaces are intentionally left as uncluttered as possible to minimize potential retention of infection and food. As many as possible of the accessories and hardware are plastic or plexiglass to minimize maintenance and contamination problems as well. It is important for avian veterinarians to recognize that as bird owners and aviculturists become more responsible in establishing disinfection programs and quarantine protocols for themselves, avian clinics will become relatively more significant sources of cross contamination between bird groups. Any degree of pathogen retention, especially viral diseases, can have devastating implications for client breeder facilities after a bird visit. Metal molding, mesh grids, exposed wires and chains are difficult to clean at best. It is also expensive to pay staff members to properly disinfect brooders. My staff used to average 40 minutes to properly disassemble, strip and scrub out an Armstrong chamber after each patient dismissal. The savings in labor alone will pay for superior equipment in a short period of time.

Each brooder is placed onto a steel tubular frame built on castors so that the brooders could be easily wheeled around the clinic or within each ward as each patient's particular case required. This greatly assists in avoiding chipped brooder corners and scratched face plates, as the large unit of 3/8" plexiglass can be formidable pieces of equipment to move manually and weigh over 100 pounds each.

The investment made in the ten units we manufactured was substantial in terms of both time and capital. We also realized that our case load of approximately 5,000 patient visits per year placed a great demand on our existing equipment and that our brooders were the single most vital element for the successful recovery of our critical and pediatric patients. We realized that even if we increased our overall recovery rate by 10% or simply decreased the recovery time period by 10%, the final impact on care provision would be significant. These figures take on even greater importance when we estimated that we were averaging a stock value of somewhere between 300 and 500 thousand dollars worth of client bird investment a year under our care and that our clients' ability to remain profitable was heavily dependent on our performance. The brooders were calculated to pay for themselves within three to six months based on a 10% improved patient recovery rate so this project was undertaken. The financial investments that were made five years ago have paid off well for our clients' breeding programs and the health of aviculture in general.

I am listing the following observations and suggestions for those aviculturists considering designing their own brooders as a way of minimizing trial and error techniques.

1. *Keep it as simple as possible.* A good design has few moving parts, smooth walls and simplistic features but accomplishes a complex goal. Make all the auxiliary equipment easily detachable.

2. *More expensive is not always better.* High quality parts, labor and materials are never cheap, but a bit of diligent research and the liberal use of parts catalogs will make a great cost difference when building multiple units.

3. *Use experienced consultants.* The electronics and plexiglass become very expensive when miscalculations force you to repurchase them. Use an experienced plexiglass shop with high quality tools. They are not inexpensive. They can also give you good advice on the materials' strengths and limitations.

4. *Learn about thermodynamics.* This area is as foreign to most aviculturists as aerodynamics, and small concepts have major function implications. I had the pleasure of working with a thermodynamics engineer, a medical instrumentation engineer and a metallurgist, and the project was still a three year challenge. I have also discarded two complete sets of brooders I built with dissatisfying results before I successfully used the current design.

5. *Pay strict attention to the heater placement.* Keep the heater unit outside of the chamber to prevent excessive material wear from heat. This also allows for quick detachment for disinfection purposes.

6. *Watch for dust built up in heater units.* Room and feather dust will become electrostatically adhered to coils and other electrically fed metal parts in the heater unit. It is critical to regularly and fully clean out the heater box to prevent smoke or fire. A room air filter such as a Norelco™, Bionaire™ or Environcaire™ will reduce the labor and risk levels dramatically.

7. *Watch fan type and placement.* Fans have some degree of vibration. Excessive vibration is very stressful to most birds under constant exposure. We found computer cabinet fans with air float bearings to have low vibration levels. Excessive wind force severely complicates brooder function. Air movement of such a level as to not noticeably blow a feather is ideal. It is very difficult to locate fans of lower than 32 CFM that have good construction. Ten to 12 CFM for each 20 to 30 cubic feet is probably a good guideline if possible.

8. *Solid state electronics.* Wafers, mechanical relays and resistors are cheaper but not as reliable. Lightbulbs can also be used as a heat source, but I do not believe a valuable handfed psittacine's life should depend on them.

9. *Evaluate your goals, and your patient's needs.* Medical brooders are as fundamental to avian practice as I.V. catheters are to canine/feline practice. Patient performance under crisis is directly linked to the quality of that product. With the value of birds rising, our ability to deliver higher quality medicine greater than ever before and ecological pressures increasing to sustain many species, it makes sense to give ourselves the best chance of fighting the primary disease process presented instead of the iatrogenic ones we create. ●