Temperature and Transport: Welfare Implications for Ambassador Ectotherms

Ectotherms such as invertebrates, amphibians and non-avian reptiles are frequently part of ambassador animal collections in zoos, and for good reasons. They are relatively easy to handle for use in educational settings (though many are great candidates for more hands-off, operant conditioning-based behaviors). Ectotherms far outnumber endotherms in the wild, where they have equally important ecological roles and are actually more often in greater need of conservation efforts. These animals therefore provide excellent opportunities to teach people about generally "less-loved" species that have fascinating evolutionary and natural histories, and which also face similar global threats as their fuzzy and feathered counterparts.

An ectotherm's body temperature is largely determined by its surroundings, and many prefer to regulate it within a relatively narrow range, which is accomplished through behavioral adjustments (e.g., shuttling between sun and shade). Replicating natural temperature conditions to ensure optimal welfare for captive ectotherms thus remains challenging—not just in permanent enclosures but during transport as well. Providing appropriate ambient temperatures for transported ectotherms is of utmost importance since they cannot behaviorally adjust their body temperature while confined in relatively small spaces that may not be within a particular species' preferred range. We sought to determine if ambassador ectotherms experience preferred temperatures while being transported during winter at a midwestern zoo—a particularly challenging time period with respect to preferred temperature replication for ectotherms. Our goal with this study was to provide quantitative evidence that a "one size fits all" approach to transport likely doesn't meet the thermal needs of all ectotherms in a given ambassador animal collection.

We conducted our study at Fort Wayne Children's Zoo (FWCZ hereafter), which has an ambassador animal collection of approximately 60 individuals (some species are accessioned as a group), and ectotherms compromise more than half of the collection. When outside ambient temperature is below 18.3 °C (65 °F), FWCZ guidelines require a hot water bottle be placed in an insulated plastic cooler (referred to as carrier hereafter) in one of two sizes—small (16 L) and large (50 L)—with an ectotherm during transport for use in on and off-site educational programs. From February to May of 2015, we placed miniature temperature loggers inside transport carriers that recorded temperature every five minutes when an ectotherm was used for programming (Fig. 1). When an ectotherm was transported with a temperature logger in its carrier, the person transporting the animal(s) also brought an empty carrier without a hot water bottle along that also had a temperature logger in it to serve as a control.

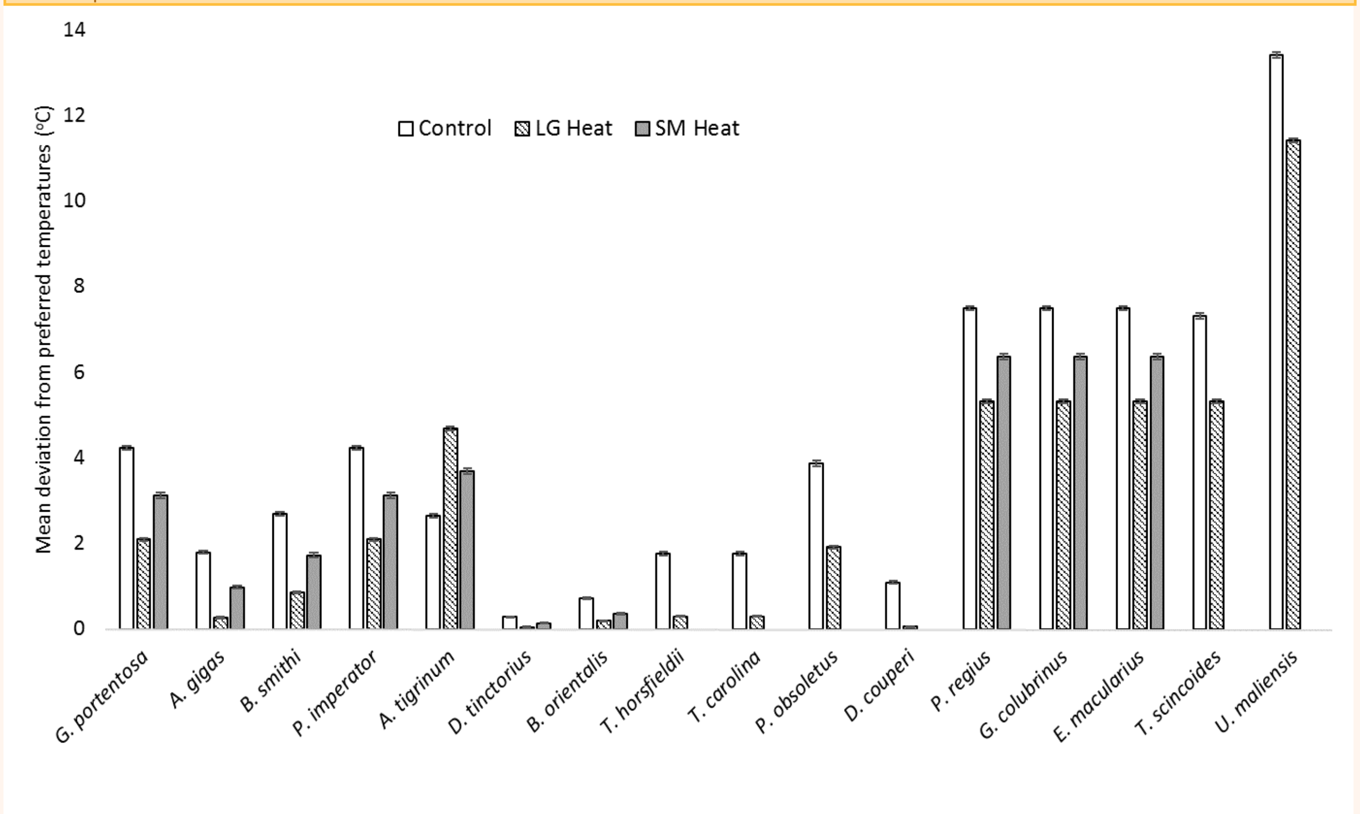
We found the preferred temperature range for each species in the study by searching through the primary literature. If not found there, we used a closely related surrogate species for which preferred ranges were known or the recommended temperatures for housing a particular species from credible sources as its preferred range (Table 1). We used the temperatures from the data loggers to create an index of "thermal quality" for each species based on carrier size and treatment (hot water bottle or control). With this index, a value of zero indicates the temperature recorded at a given time was within the preferred range of a given species (i.e., perfect thermal quality), and thermal quality decreases the more temperatures deviate from a species' preferred range (i.e., the higher a numerical value indicates worsening thermal quality).

We found hot water bottles influenced carrier temperatures, as both sizes of heated carriers were warmer than either size of control carrier. Large heated carriers were significantly warmer than small heated and control carriers (ANOVA with Tukey post hoc test, $P<0.001$), but large and small control carrier temperatures did not significantly differ ($P=0.66$). We obtained a total of 3,798 temperatures from loggers placed in large heated ($n=1{,}076$), small heated ($n=823$), and control ($n=1{,}899$) carriers in 26 individual transportation events; large heated carriers were transported 10 times, and small heated carriers were transported 16 times. The average amount of time an animal was away from its primary enclosure with a logger recording data in a carrier during a given transportation event was 4.30 (range 2.30–8.25) hours.

There was considerable variation in thermal quality of carriers for each species depending on carrier size or treatment. Large heated carriers were higher in thermal quality than small heated carriers, which, in turn, were both higher in thermal quality than control carriers for nearly all species (ANOVA with Tukey post hoc test or paired t-test; P<0.001). The only opposite of this trend was observed for Eastern Tiger Salamanders. Thus, control carriers provided the highest thermal quality environment for this species. Overall, carrier

Figure 1. Eastern Tiger Salamander being transported for an outreach program with a hot water bottle. A temperature logger can be seen taped to the inside center of the transport carrier.

Figure 2. Comparison of mean 3 standard error intraspecific values of thermal quality of control, large heated (LG Heat) and small heated (SM Heat) transport carriers. A missing bar for SM Heat for a particular species indicates it was not transported in small carriers. As this measure of thermal quality was determined by calculating the absolute value of the deviations of carrier temperatures from each species' preferred temperature(s), the larger the intraspecific value for each carrier treatment indicates decreasing thermal quality. Mean carrier thermal quality values were significantly different (P<0.001) between treatments for all intraspecific tests.



temperatures were most appropriate for turtles and most invertebrates and amphibians. Thermal quality of carriers was lowest (too cool in this case) for most tropical and desert reptiles, notably Spiny-tailed Lizards (Fig. 2).

Our results demonstrate that a "one size fits all" approach to ectotherm transport clearly does not meet the thermal needs of all ambassadors in a given collection, as some species were transported at temperatures that were either too high or too low from their preferred ranges. While there is much more work to be done for providing appropriate thermal environments for temperature-sensitive species, FWCZ has ceased using hot water bottles when transporting their tiger salamander since the completion of this study. Given that nearly all physiological processes (e.g., digestion and immune responses) are temperature-dependent, impeding thermoregulation may have negative welfare implications. From communication with other zoos, we have learned that transport methods can be somewhat similar between institutions, yet different enough to warrant a study of their own. We therefore suggest other institutions investigate and report the appropriateness of their own transport methods. We also urge for further applied welfare research, such as coming up with species-specific solutions to providing appropriate temperatures for ectotherms during transit.

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Species	Preferred temperature(s)°C
Madagascar hissing cockroach (*Gromphadorhina portentosa*)	26.7 - 29.4
African giant millipede (*Archispirostreptus gigas*)	23.9 - 29.4
Mexican red-kneed tarantula (*Brachypelma smithi*)	25.0 - 27.0
Emperor scorpion (*Pandinus imperator*)	26.7 - 30.6
Eastern tiger salamander (*Ambystoma tigrinum*)	20.0
Blue poison dart frog (*Dendrobates tinctorius*)	21.0 - 27.0
Oriental fire-bellied frog (*Bombina orientalis*)	22.0 - 26.0
Eastern Box Turtle (*Terrapene carolina*)	24.0 - 31.9
Russian tortoise (*Testudo horsfieldii*)	24.0 - 35.0
Ball python (*Python regius*)	30.0
Kenyan sand boa (*Gongylophis colubrinus*)	30.0
Ratsnake (*Pantherophis obsoletus*)	26.5 - 29.8
Eastern indigo snake (*Drymarchon couperi*)	23.0 - 28.0
Leopard gecko (*Eublepharis macularius*)	30.0
Blue-tongued skink (*Tiliqua scincoides*)	30.0 - 37.0
Spiny-tailed lizard (*Uromastyx maliensis*)	36.1 - 38. 0

Table 1. Ectotherms used in educational programs at the Fort Wayne Children's Zoo and the preferred temperature(s) of each animal.