The Tortoise Trust
BM Tortoise, London, WC1N 3XX

*A comparative analysis of indoor housing systems for terrestrial tortoises*

# PART ONE

## Glass tank type vivarium habitat


The Jon Coote Tortoise Starter Kit

www.tortoisetrust.org

# Tortoise Vivarium Test Series

**Introduction:**

There has been much discussion on the comparative merits (and disadvantages) of various types of indoor accommodation for tortoises. Three kinds of unit are in common use today:

1) Enclosed or semi-enclosed glass vivarium
2) Open-topped tortoise vivarium (also known as a 'Tortoise Table')
3) Enclosed wooden vivarium

In view of the conflicting claims made for each type of unit, the Tortoise Trust decided to conduct a series of in-depth tests to establish how the units performed by measuring a number of important parameters that are widely accepted as being of considerable importance to chelonian health:

a) Peak basking temperature achievable
b) Substrate temperatures achieved
c) Temperature gradients available within the unit
d) Relative humidity range within the unit
e) Provision of UV-B
f) Provision of suitable substrate and micro-climates

In the case of ready packaged vivaria, we also assessed the quality of the accessories and instructions provided. The test was conducted in three stages. The first tests analysed a popular enclosed glass tank-type vivarium. The second series of tests added comparative data from a typical wooden terrarium with sliding glass doors. The final series of tests contributed data from the open-topped 'Tortoise Table' type installation now popular with many advanced level keepers. All three habitats are frequently promoted as being suitable for use with Mediterranean, Leopard and Russian tortoises.

**Methodology:**

Efforts were made to conduct comparative tests simultaneously, or at least in as similar conditions as possible, to avoid distortions caused by varying ambient conditions. Where there was a significant difference in ambient conditions, these are noted. Temperature and relative humidity was recorded using multiple precision data loggers (models SL54TH and SL54USB supplied by Signatrol UK Ltd.) and graphed using TempIT Pro software. Additional measurements were taken using a Fluke model 62 Infra-Red non-contact thermometer, a dual channel K-type thermocouple differential thermometer, and a Fluke model 971 ambient temperature and humidity meter. Surface, sub-surface and ambient temperatures were also monitored and cross-checked using a precision, fully calibrated Comark PT100 reference grade thermometer. UV-B measurements were recorded using a Solar Meter 6.2 (Solartech, Inc.). We standardised the tests and probe measurement positions as closely as the various habitat designs physically allowed. The normal tests included:

1) Basking temperatures obtained directly under basking lamp, at surface height
2) Minimum temperature within unit to establish gradient available
3) The temperature of the substrate itself at the basking position
4) The effect of any ancillary heating devices provided, e.g. heat mats
5) Humidity at the basking position
6) Humidity at the furthest end of the unit
7) Humidity and temperature in any micro-climate options provided
8) UVB levels within the unit using the lamp provided (or recommended) and popular alternatives

**Basic requirements of tortoise vivaria**

Any unit to be used for accommodating tortoises indoors must be capable of providing a range of temperatures that comply with the animals POTR (Preferred Optimum Temperature Range) and which also permit active thermoregulation by providing a cooler, retreat area in addition to a higher temperature basking site. For most Mediterranean tortoises (Genus *Testudo)* this will typically equate to a basking position capable of providing an absolute minimum of 30 ˚C to a maximum of circa 38 ˚C. The cooler retreat area should provide temperatures in the range 18-24 ˚C. Overly high temperature basking temperatures should be avoided. Studies on Mediterranean tortoises suggest that the critical thermal maxima is in the 39.5 to 41 ˚C range, at which point death can occur quite rapidly (Hutchinson, Vinegar and Kosh, 1966, Cherchi, 1959). The tortoise genera with the highest known critical thermal maxima is the North American *Gopherus,* with *Gopherus agassizzii* at 43.1 ˚C, *Gopherus berlandieri* at 42.8 ˚C and *Gopherus polyphemus* at 43.9 ˚C.

Voluntary maximum body temperatures of wild-living *Testudo graeca* and *Testudo hermanni* ranged from 33 ˚C to 35 ˚C (Meek and Jayes, 1982), with most rarely exceeding 34 ˚C (Avery, 1982; Meek & Avery, 1982). Studies on *Testudo ibera* living wild in the North Caucus indicate a typical body temperature during activity of 29.1 ˚C, and a point of overheating of 39 ˚C. (Kuzmin, 2002). Similar studies in Africa on Leopard tortoises, *Geochelone pardalis*, indicated a preferred mean body temperature of 32.5 ˚C, with an absolute maximum of 38.4 ˚C observed, which was accompanied by salivation, suggesting that this figure approaches the critical thermal maxima for the species (Hailey and Coulson, 1996). For the Horsfield's (or Russian) tortoise in Turkmenia (*Testudo horsfieldii*) maximum activity appears to occur between 20-32 ˚C ( Ateyev, 1985). The voluntary maximum of this species is cited as 34-35 ˚C (Pritchard and Greenwood, 1968). At higher temperatures in nature, estivation occurs (Chernov, 1959).

All available evidence suggests that species which inhabit shady areas by preference, for example North American box turtles (*Terrapene* sp.), South American Redfoot tortoises (*Geochelone carbonaria*), or African hinge-back tortoises (*Kinixys* sp.) have a considerably lower POTR than basking species from more open, arid environments. For example, in the case of *Terrapene ornata* preferred average body temperatures are in the region of 27.5 ˚C (Rose, 1988), while for *Kinixys spekii* a figure of 27 ˚C was established (Hailey and Coulson, op. cit). These species also feature much lower critical thermal maxima.

It is imperative that where a high temperature basking spot is available, an area where the animal can rapidly cool down is also accessible at all times. Excessively high basking or substrate temperatures (defined as over 40 ˚C) are increasingly hazardous to all species

and should be avoided within accommodation intended for chelonia. This is especially true where hatchlings and small juveniles are to be accommodated, as these can easily become inverted under the basking lamp and their low body mass will result in fatal overheating within a very short period of time, often just a matter of minutes.

**Humidity requirements**

Different species will have very different needs in terms of environmental humidity. Broadly speaking, these requirements closely correlate to the type of habitat they originate from. As a general guide, tropical forest species may require an average RH of 80% or more, while a typical arid habitat species will require the ambient RH to be in the 45-55% range. Subjecting species to extended sub-optimum levels of humidity can have serious consequences for long term health as it will produce a state of chronic dehydration.

Suitable micro-climate provision will help to limit fluid loss from evaporation (which occurs via the skin and as a result of respiration), and will also help to stabilise sudden body temperature fluctuations. Micro-climates are, therefore, very important to tortoises and they are utilised extensively in the wild by many species, and are of particular importance to species that inhabit inhospitable arid environments. This type of behaviour is not unique to tortoises, being particularly common among lizards, and the physiological results also closely parallel those established in other reptiles (Heatwolfe and Taylor, 1987, Zug, Vitt and Caldwell, 2001). In practice, providing a cooler area where a tortoise can bury its softer parts in a sufficient depth of substrate will do much to reduce respiratory and evaporative losses, and such a facility should be made available in all enclosures.

While excessively dry environments should be avoided, so too should excessively moist or damp environments. The correct environment should be dictated by the natural habitat. As a guide, drier substrates (<60% RH) should be avoided for most forest dwelling species, and damper substrates (>60% RH) should be avoided for arid habitat species. Extensive studies on burrow habitat micro-climates in both North America and North Africa suggest that for Desert tortoises (*Gopherus agassizzii*) and Spur-Thighed tortoises (*Testudo graeca*) a substrate or burrow micro-climate offering circa 40-45% RH would closely approximate that found in nature (Bulova, 2002 and Highfield and Bayley, 1996). Excessively damp substrates or retreats can have serious implications for the health of arid habitat species, resulting in an increased incidence of respiratory disease, and an increase in both fungal and bacterial shell and skin infections (pers. obs). As a general recommendation for Testudo and semi-arid *Geochelone* species, such as *Geochelone pardalis*, air humidity within an enclosure should normally be in the region of 50% or slightly less. Fresh drinking water should be available for all species, at all times.

**Space requirements**

Tortoises require as much horizontal floor space as possible. In the wild, they roam over extremely large areas. Individual Leopard tortoises (*Geochelone pardalis*), for example, have a home range from 58 hectares to 414 hectares, with long distance movements of up to 4 Km at a time being recorded (McMaster, 2001). Smaller tortoises such as the Mediterranean *Testudo* will also roam over several hectares regularly. No vivarium can possibly approximate this. Such habitats should therefore be regarded as for temporary use only, for example during inclement weather, and additional, much more extensive outdoor accommodation is mandatory in all cases. In the view of the Tortoise Trust, no tortoise should be sold on the basis that it can be maintained indoors. It should be noted that tortoises do not possess a diaphragm (O'Malley, 2005 ) and that respiration is

dependent upon the serratus, abdominal obliquus, pectoralis and transverus abdominus muscles for inhalation and exhalation. Lack of exercise can result in muscular atrophy and may consequently contribute to the high incidences of respiratory problems observed in tortoises maintained exclusively in restricted indoor habitats.

**Glass Vivarium Test**

**Model: The Komodo Jon Coote Tortoise Starter Kit**

This vivarium is typical of the all-glass, enclosed vivarium systems promoted by many pet stores throughout the world as being suitable for the permanent maintenance of tortoises indoors. The unit as supplied measures approximately 80 cm in length by 45 cm deep X 49 cm high. The internal floor area is approximately 0.36 sq. metres. This is subdivided into two areas by a glass ridge, a smaller area measuring 42 cm X 27 cm and a larger area measuring approximately 42 cm X 52 cm. There is a fine mesh top, and an additional ventilation opening made of the same mesh on the right-hand side of the unit measuring approximately 15 X 42 cm. Supplied with the unit was a non-UVB emitting 100 watt spot lamp branded “Komodo Day Basking Light”, a small 12 watt heat pad measuring 28 X 28 cm, a ceramic holder in a dome aluminium reflector, a 4 kg bag of what is described as “pure calcium carbonate substrate”, a pack of 270 g block of compressed fibrous material described as “Komodo tropical terrain compact block”, two watering dishes, one medium and one small, two plastic thermometers, a small (16 g) plastic bag containing what appeared to be dried moss, a 170 g container of cucumber flavoured pellet form “Komodo complete holistic tortoise diet” and a 105 g container of “Komodo Calcium Supplement with Vitamin D3”. As the supplied lamp produces no UV-B whatever, the tortoise will be completely reliant upon oral supplements within this vivarium. The catalogue illustration suggested that a small hide of some form would also be provided, but this was not present in the kit we purchased. Two small instruction sheets were also included. One is devoted to the correct use of the heat pad, the other is more general and includes advice on temperatures, hygiene, feeding and watering. These instructions state that the kit is “designed to provide everything that is essential to the welfare and success of keeping many pet tortoises with a straight-line carapace length of 40 mm up to 150 mm (1.5”-7”)”.

The unit is equipped with two sliding front doors with a securing mechanism. The mesh top is held within a plastic latching framework and may be removed for cleaning. The basking lamp, fitted inside its holder and reflector rests directly upon this screen top.

We began the tests by setting the unit up exactly according to the supplied instructions for a Horsfield’s tortoise, at an ambient room temperature of approximately 21 ˚C (which is widely accepted as being typical of a centrally heated domestic room). The basking lamp rested on the right hand side of the top, and the heat pad was fixed to the rear wall at the same end. This is where we encountered the first problem. No tape of any kind was supplied to affix the heat pad. Double-sided tape is normally recommended for this purpose. Fortunately, we had some available. A normal purchaser would have to obtain this separately. We affixed an insulating polystyrene tile using the same method (as recommended but also not included) to the rear of the pad to prevent excessive heat loss.

We began the test by turning on the rear mounted heat pad for 60 minutes to allow the unit to stabilise, then at 8.45 am turned on the supplied basking lamp. We then recorded the time taken to achieve maximum basking temperature at substrate level directly under the lamp (Fig 1.)

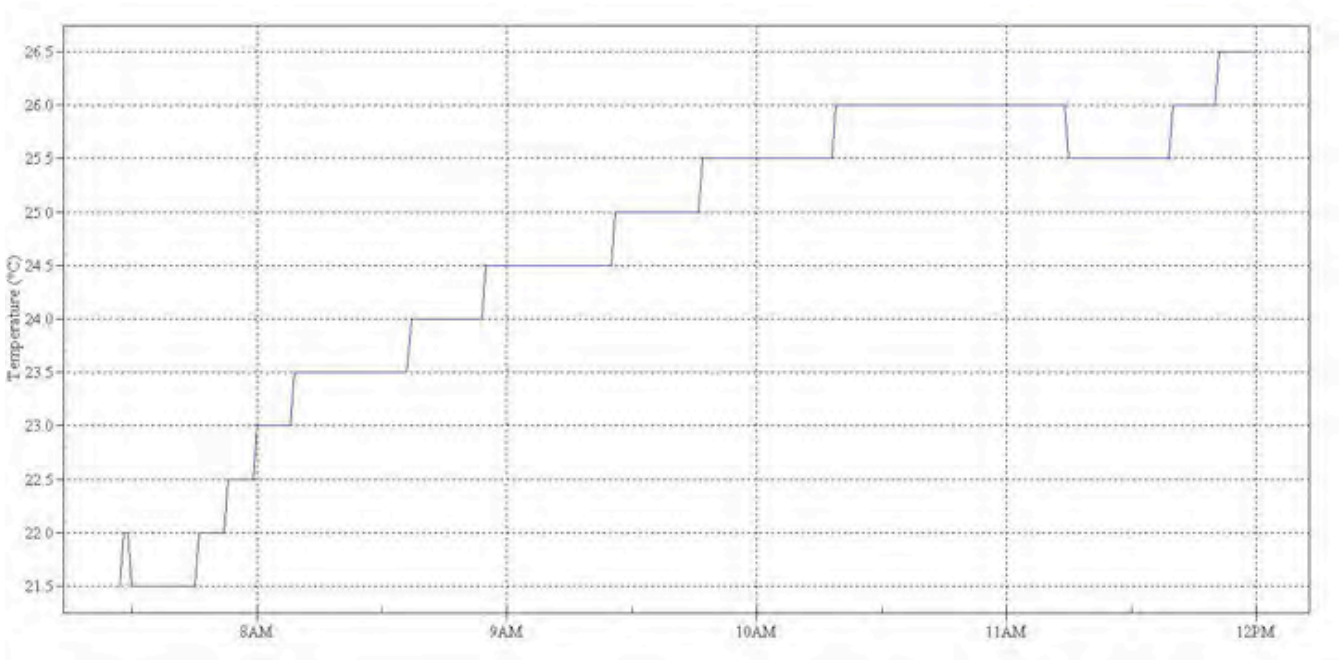



Fig 1.

The temperature rose very slowly, taking almost 3 hours to attain 26 ˚C. It then peaked at 26.5 ˚C and stabilised. These results suggest to us that the supplied basking lamp is under-powered or is situated too high above the basking site. There is no means of adjusting this, unfortunately. Typically, a vivarium basking lamp will produce maximum basking temperature in 30 minutes or less. In this case, it took 2 hours to rise from 23 ˚C to 25 ˚C. An acceptable *minimum* basking temperature for tortoises is 30 ˚C, with somewhat higher temperatures being preferred. These results were so surprising that we repeated the test to confirm that the unit was incapable of providing an adequate basking temperature for tortoises.

Starting from a 20.5 ˚C internal temperature (with the rear mounted heat pad running), the basking lamp was turned on at approximately 12.10 p.m. and monitored continuously. The lamp was then turned off at 3.00 p.m. and the temperature decay recorded (Fig 2).

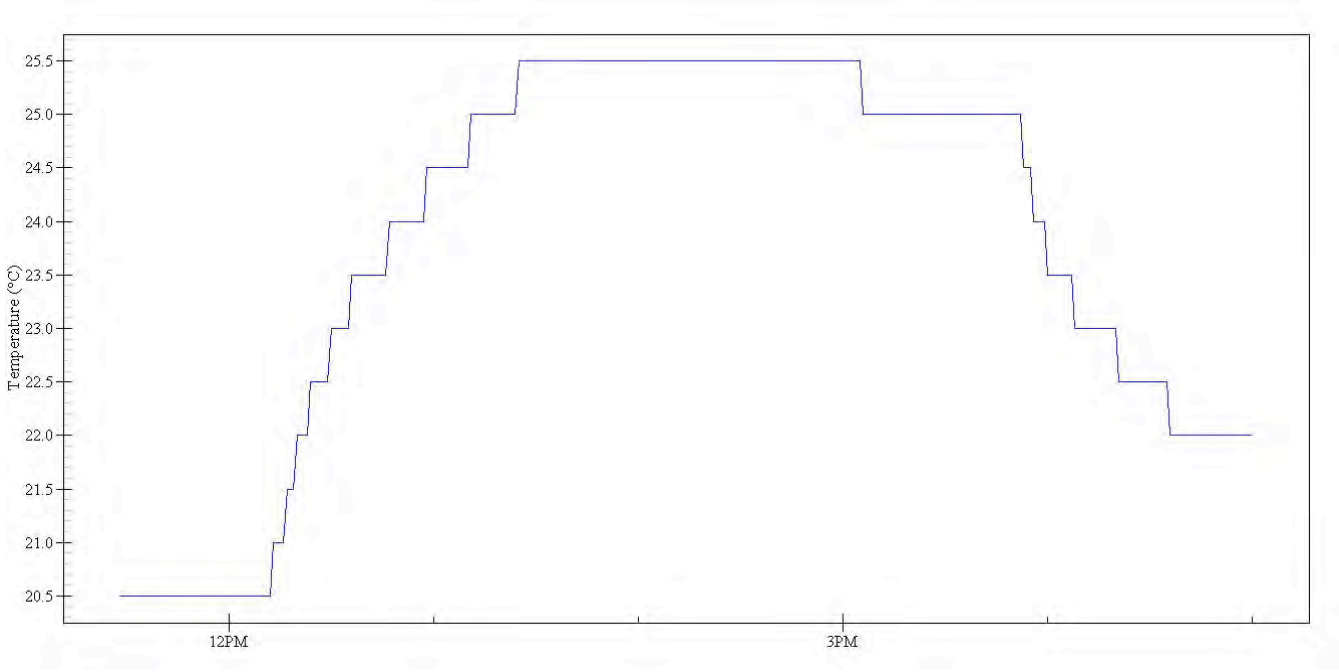



Fig 2.

These results again indicate that the unit fails to provide an adequate basking temperature for tortoises if the heat pad is mounted on the rear wall as suggested. In this test, the maximum temperature achieved was 25.5 ˚C (this was almost certainly due to the background temperature at the start of the test being a full 1 ˚C lower than in the first test). It should be noted that the temperature achieved in both tests would probably be inadequate to promote vitamin D3 production even if a UV-B lamp was provided (Baines, pers. comm.)

The next test sought to establish the temperature gradient available within the unit and was conducted simultaneously with the test described above. A second probe was positioned at the far end of the tank, away from the basking position.

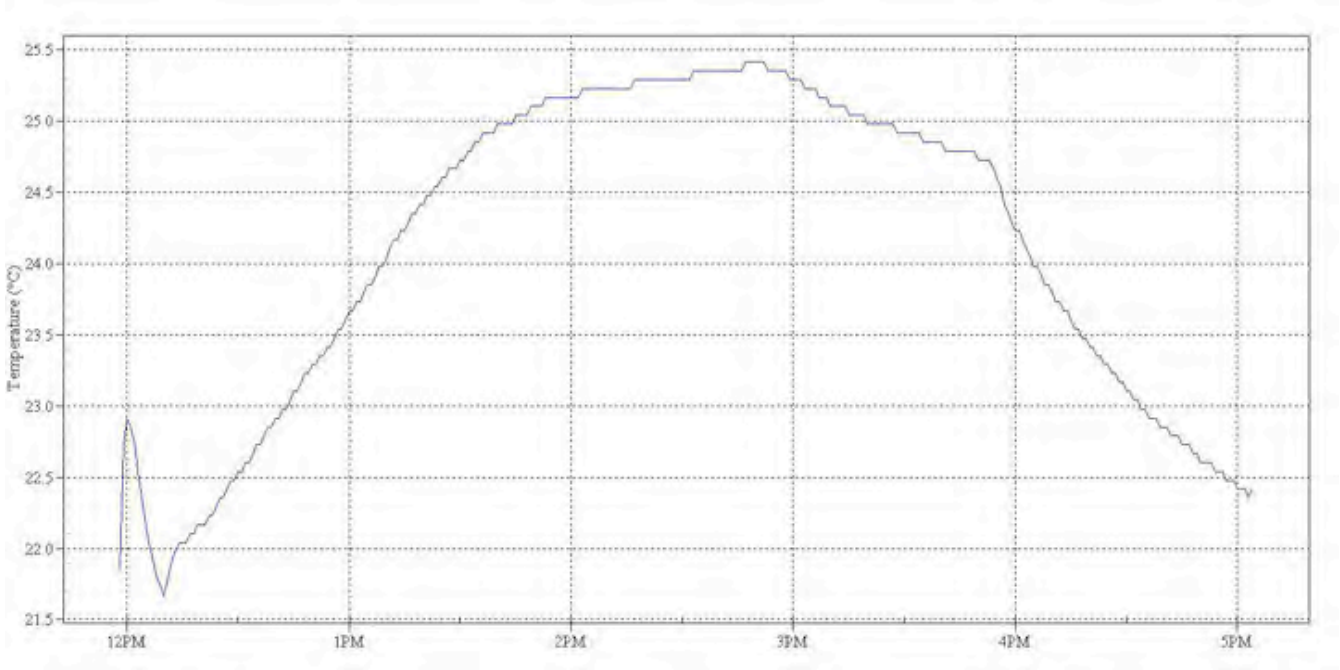



Fig. 3.

The results of this test reveal that the Jon Coote vivarium design offers almost no temperature gradient whatsoever to its inhabitants, even when set up exactly as directed on the provided instruction sheet. At 1.00 p.m. the temperature at the basking position is approximately 24 ˚C. The far end of the tank offers just over 23.5 ˚C. By 2.00 p.m. the basking site offers 25.5 C, while the far end of the unit offers approximately 25.25 ˚C. At 3.00 p.m. the basking site is still at 25.5 ˚C, while the far and of the unit offers approximately 25.25 ˚C. The provision of an adequate temperature gradient is a physiological necessity for tortoises. Failure to provide this will result in stress, a compromised immune system and ill-health. **Under no circumstances should tortoises be confined within a habitat that is incapable of meeting their basic physiological needs.** The provided instructions acknowledge the need for an adequate gradient (though they do not specify what it should be). It is generally accepted that a minimum 8-10 ˚C differential is required. It has been suggested that a gradient that provides at least 80% of the variation experienced by the species in nature would be ideal (Anderson, undated). For most species this means that an optimal habitat would offer a differential of 15 ˚C or more between the basking site and the cool retreat zone.

In view of the fact the unit consistently failed to provide an adequate basking temperature or an acceptable temperature gradient with the supplied heat pad mounted on the rear wall, we then proceeded to test it with the heat pad in the alternate recommended position fitted under the base of the tank (Fig 4). The probe rested on the surface of the substrate.

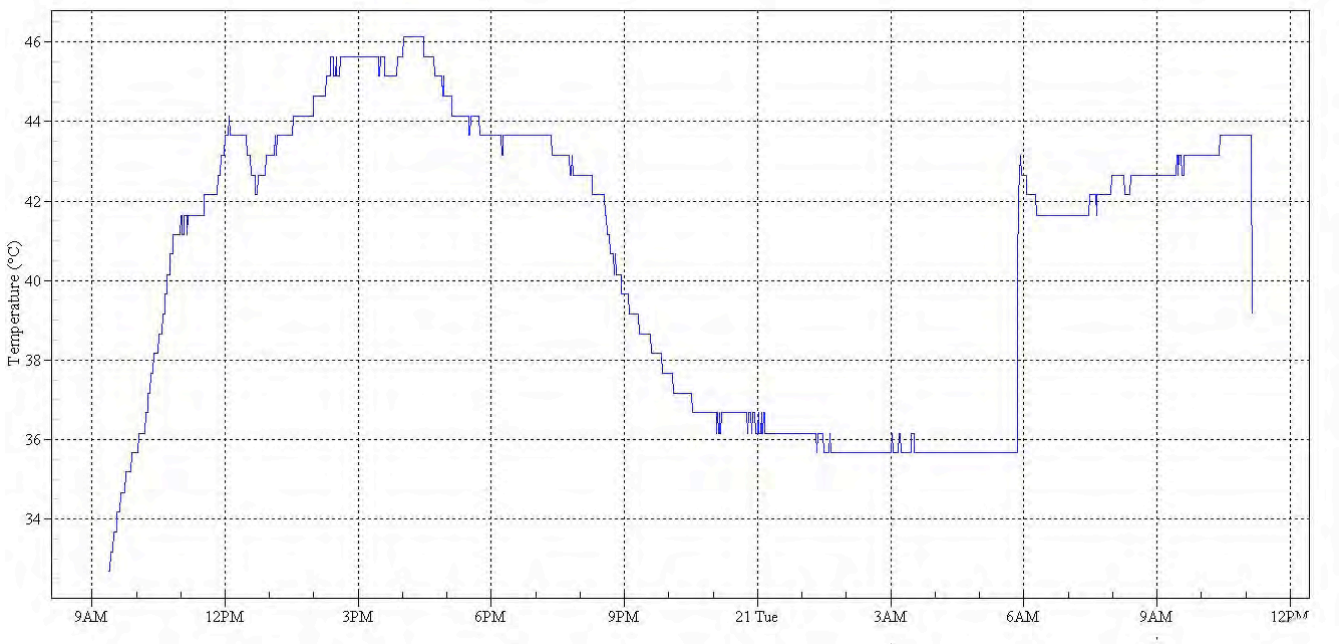



Fig. 4

This was a long term test that ran from 9.10 a.m. one day until 11.00 a.m. on the following day. The heat pad was covered with the recommended maximum depth of supplied substrate (1 cm). It will be noted that the temperature under the basking lamp rose to 36 ˚C by 10.00 a.m., but then continued rising inexorably to a peak of 46 ˚C. The lamp was turned off at 6.00 p.m., while the heat pad remained on for the duration of the test. Overnight temperatures were monitored, and remained in the region of 36 ˚C. At 6.00 a.m. the basking lamp was again turned on, and temperatures rose rapidly to 42 ˚C. The test was terminated at 11.00 a.m.

Substrate temperatures of 46 ˚C are completely unacceptable and are extremely hazardous, especially to small tortoises. This is significantly above the critical thermal maxima of all known chelonia. According to McArthur (2004) “Heating chelonians from below is fraught with potential danger and may cause ventral burns, deranged digestion and inadequate heat dissipation through the animal” and “whenever ventral heat is applied to a chelonian it should be thermostatically controlled, protected from excessive localised heat output, and regularly serviced”. No thermostat is included with the Jon Coote Tortoise Starter Kit. McArthur (op. cit) also states “Ventral heat mats are inappropriate heat sources... the digestive tract lies relatively unprotected from heat just above the plastron within the coelomic cavity. Heating this area increases the digestive processes and can derange gut fermentation resulting in rupture of the small or large intestine and even death. This author (SM) has been presented with several hatchlings where use of ventral heat mats has resulted in gut rupture and death and strongly advises against this form of heat provision”. The Tortoise Trust has also encountered a number of such cases. We entirely concur with the advice of McArthur (op. cit) that dorsal (overhead) provision of basking heat should be used *exclusively* with temperate tortoises, and that where heat pads are employed, they should only be used in the role of providing background heating, and should be fixed to a rear wall. They should not ever be used to provide basal heat at a basking site.

These results were very disturbing, so to confirm them, we ran the test a second time, and additionally recorded the temperature just beneath the surface of the substrate, and the also the relative humidity at the basking position and at the far end of the tank (Fig. 5).

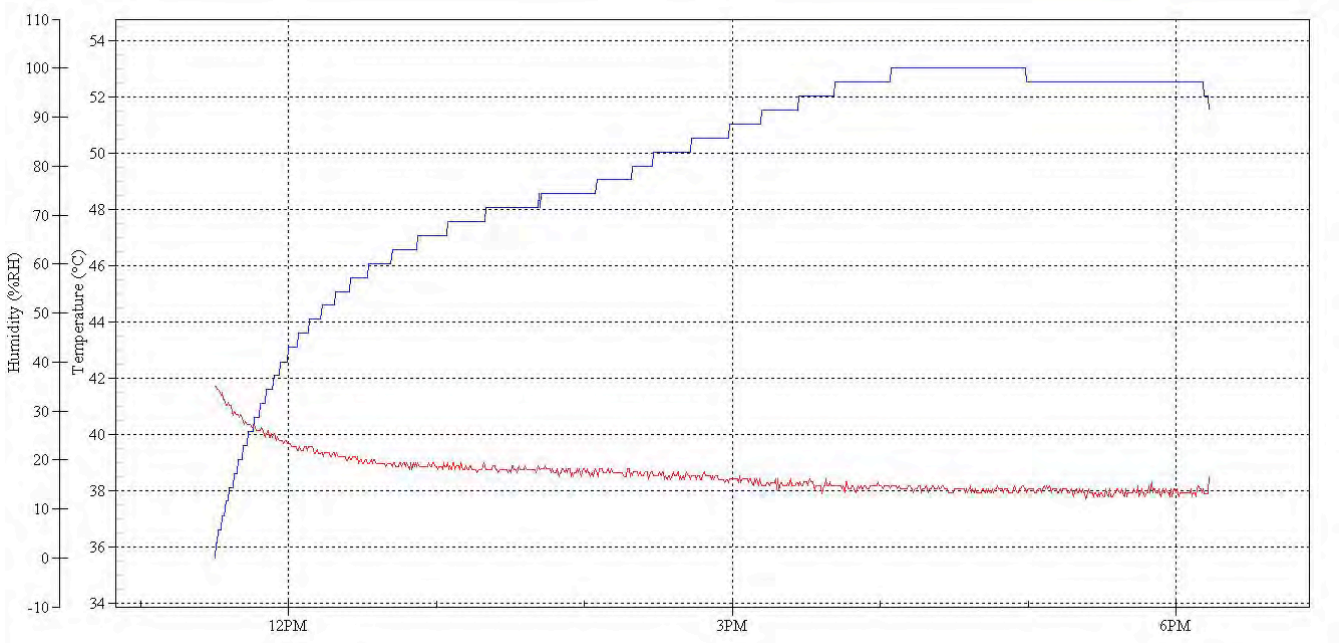



Fig. 5

The sub-surface (approximately 5 mm deep) probe recorded a peak temperature, in this test, of approximately 53 ˚C (127.4 F). O'Malley (2007) states that "reptiles suffer easily from thermal burns". McArthur (op.cit) further states that " Excessive ventral heat... may create dramatic burn injuries to the plastron and ventral limbs, and result in vast areas of shell necrosis". Mitchell and Tulley (2008) also caution against electric heat pads that are in close contact with reptiles stating that they "have the major disadvantage of causing thermal burns and are difficult to regulate". Several authors comment that thermal burns in captive reptiles due to the use of heat pads are one of the most common trauma injuries seen in practice. Anderson (undated) comments that "heating elements that can attain temperatures over 105 ˚F (40.5 ˚C) can produce life threatening thermal burns" in reptiles and advises that to "decrease the likelihood of thermal burns..... be certain that the surface temperature at the hottest spot is less than 105 ˚F." **The substrate temperatures recorded in these tests are unacceptably high, and in our opinion are extremely dangerous and are capable of causing severe injuries and rapid fatalities.** The absence of a thermostat only serves to exacerbate these hazards.

The lower (red) line on the chart indicates the relative humidity at the basking site. This commenced at 39% and rapidly fell to approximately 15% where it stabilised. This is exceptionally low, even for a desert reptile. Humidity is discussed in more detail later.

A second set of measurements was recorded at the far end of the tank to establish peak temperatures, gradients, and relative humidity. These results are shown in Fig. 6.

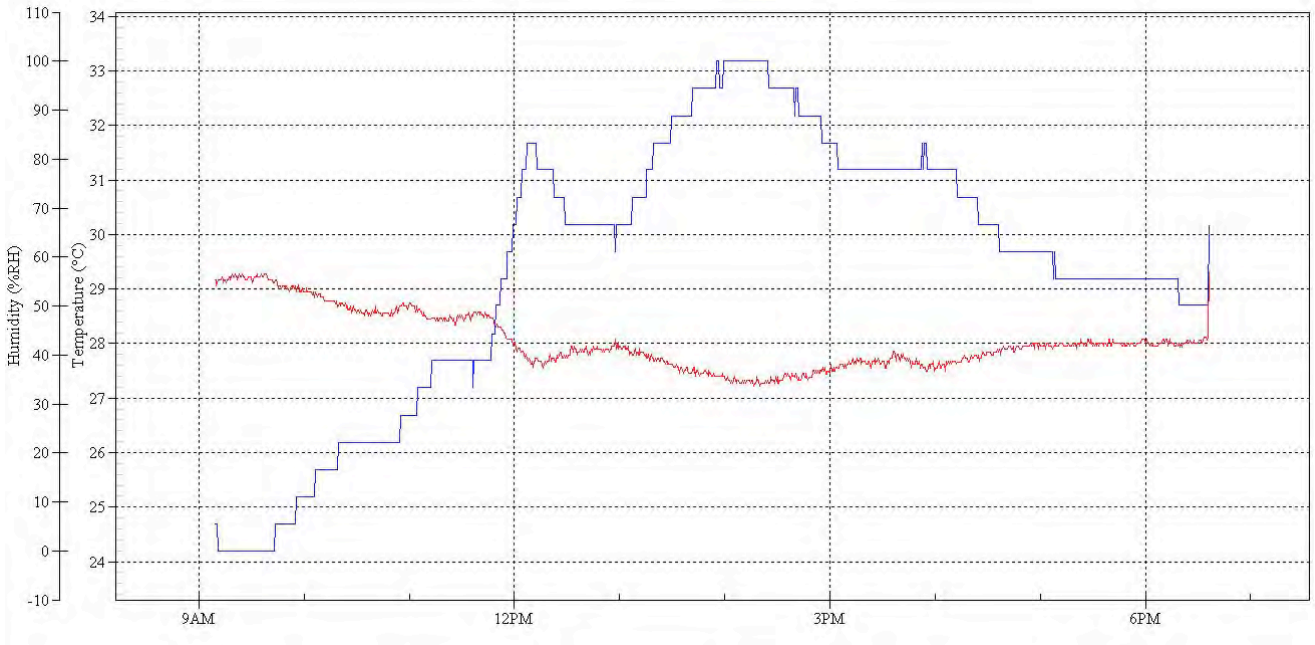



Fig. 6

This graph (temperature = blue line, humidity = red line) shows the temperature and humidity at the far end of the tank away from the basking site and heat pad. The humidity at the far end of the tank when the test commenced was approximately 55% and fell to a minimum of approximately 33%. It remained at or below 40% for in excess of 6 hours. The major concern with these results is that at one stage the "coolest" area within the tank measured in excess of 33 ˚C and remained above 30 ˚C for over 4 hours. This is more appropriate as a peak basking temperature. It is totally unacceptable as a cooler area for the purposes of thermoregulation. From 12.00 p.m. to 6.00 p.m the minimum temperature available to any tortoise in this vivarium (100 watt basking lamp, under-floor heat pad configuration) would have been above 29 ˚C. **There is no doubt whatever that these temperature readings demonstrate that the unit as supplied, as as set up in accordance with the instruction sheet, fails completely to provide a range of effective and safe temperatures suitable for the proper maintenance of tortoises (of any species).** The temperature obtained is either too low (vertically mounted heat pad) or excessively and dangerously high (under-floor mounted heat pad). We attempted a number of different configurations, and in none could we produce a combination of safe and effective basking temperature together with an acceptable gradient and appropriate cool zone. The very low relative humidity available is also of major concern: a typical humidity gradient from 15% to 40% is not appropriate for any tortoise on a sustained basis, including *Testudo horsfieldii*, and would be likely to lead to chronic dehydration with a consequential increased risk of renal disease or the formation of bladder stones (calculi). The instructions do stress the importance of providing fresh water daily, but it is unclear of this would be adequate to mitigate the extreme levels of fluid loss caused by a sustained relative humidity as low as 15%.

The supplied instructions suggest that the humidity within the tank can be controlled to suite most tortoises, except for Horsfield's tortoises (*Testudo horsfieldii*), which it is claimed "like everything very dry". We disagree with that simplistic analysis. Like many other arid habitat species, *Testudo horsfieldii* actively seeks out more moderate micro-climates using scrapes and deep burrows, and ceases activity entirely by means of estivation when conditions become too hot and dry.

The conditions generated by a “dry” tank installation as recommended are illustrated in Figures 1 though 6. We therefore next assumed that the tank would accommodate *Testudo graeca* or *Testudo hermanni* and consulted the instructions for guidance on how to establish a suitable environment for these tortoises. It is recommended that the “Forest Terrain substrate can be used very slightly moist at the cool end of the tank” and that “the moss provided should be kept damp and placed inside the log hide at the cool end of the tank”. It is claimed that tortoises “use similar comfortable damp hollows and burrows in the wild”.

From the outset we experienced considerable problems with the supplied “Komodo Tropical Terrain” substrate. We soaked it as directed for 45 minutes in 3 litres of water. We then spread it out thinly on a plastic tarpaulin in full sun in an effort to dry it so that it was “slightly humid” . After 3 hours in full sun and warm breezy conditions it was still completely saturated. The instructions refer to placing it near a radiator or similar domestic heat source. We can understand why. We finally resorted to “baking” it on two 25 watt heat pads and using a hair drier. After a further 4 hours we placed it within the tank. Keeping this product “slightly humid” (more accurately, slightly moist) proved exceedingly challenging. We feel that this substrate is excessively difficult to prepare and is far too difficult to maintain within suitable and safe parameters.

To establish the properties of the environment generated by this method, we precisely followed the instructions for the preparation of the substrates and for the layout of the tank. The supplied sand substrate was located in the smaller “desert” area on the right-hand side of the tank, and the “forest” substrate was distributed over the left-hand, larger area. As our unit had been supplied with the log hide absent, we substituted one of similar size and design, and filled this with the moss prepared as instructed. Due to the problems noted in getting the substrate prepared, we allowed the unit to stand for a further 12 hours with the heat switched on to stabilise before beginning any trials. An initial set of measurements taken with a laboratory grade dual channel differential thermometer equipped with fast reaction K-type thermocouples indicated that if the heat pad was mounted on the rear wall the temperature in the basking zone was limited to an inadequate 26.5 ˚C (which was identical to the results of previous tests). The same instrument simultaneously recorded a surface substrate temperature of 20.7 ˚C at the far end of the tank and an air temperature in the same position, but taken 75 mm above the substrate, of 23.2 ˚C. Subjectively, the “Tropical Terrain” substrate felt cold and noticeably damp to the touch (despite these measurements being taken after time allowed for stabilisation and despite our best efforts to comply with the advice that it should be only “slightly” moist). Spot checks with a Fluke 971 humidity meter also revealed that the relative humidity of the air 50 mm above the substrate in the “cool” end of the tank was 79.8% and that it was 64.4% at the “hot” end of the tank. We therefore determined that the full test would be conducted using the under-tank heat pad as this appeared to be the only method of attaining a higher overall temperature within the vivarium.

We then placed two data-loggers to record temperature and humidity at each end of the tank, one centrally located just beneath the surface of the dry substrate at the basking site, and the other we placed within the log hide (Fig 7). We also placed a third humidity logger suspended in free air at a height of 30 cm and located centrally within the tank to record the overall humidity attained within the environment.

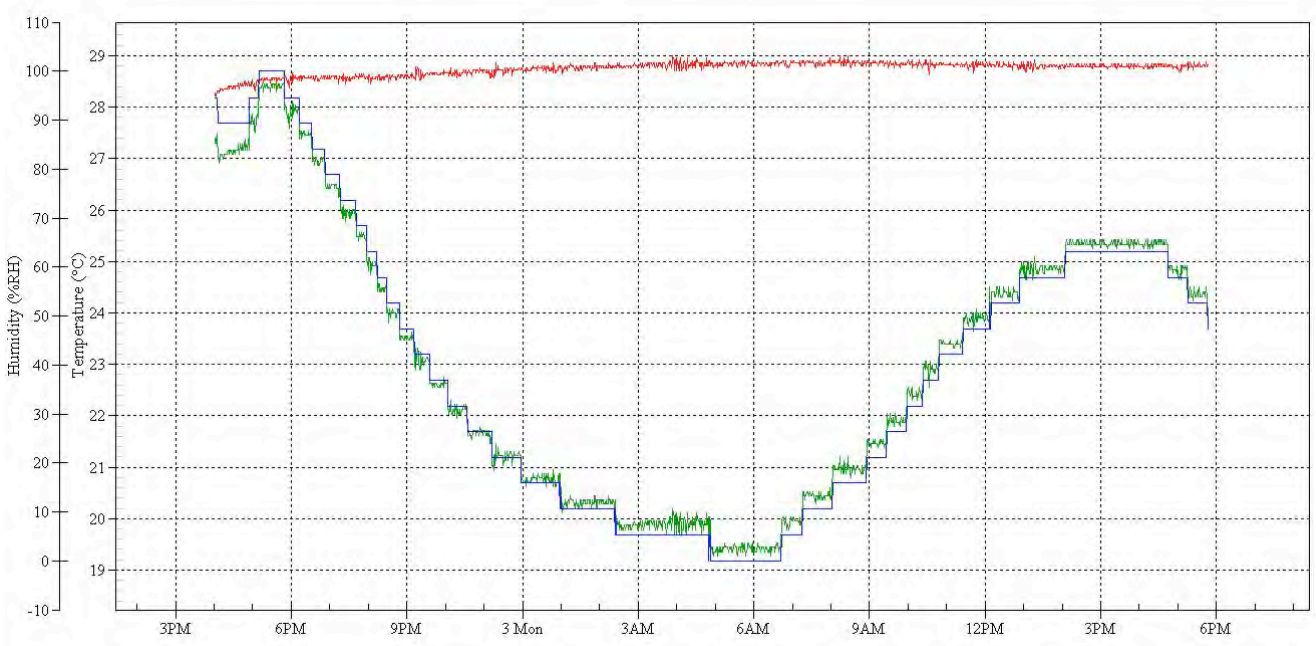



Fig. 7

The red line indicates the relative humidity, the blue line the temperature, and the green line the dew point recorded inside the hide from 3.30 p.m to 6.00 p.m. the following day. It will be noted that the relative humidity within the hide ranged from 95% to 100%. It remained at 100% even when temperatures fell to below 20 ˚C during the night. The dew point tracked the temperature almost precisely. The net result is that this hide was not merely humid - it was wet. Subjectively, it felt wet and cold (due to the high rate of evaporative cooling). The central, suspended sensor provided the general ambient conditions within the vivarium at this time (Fig 8).

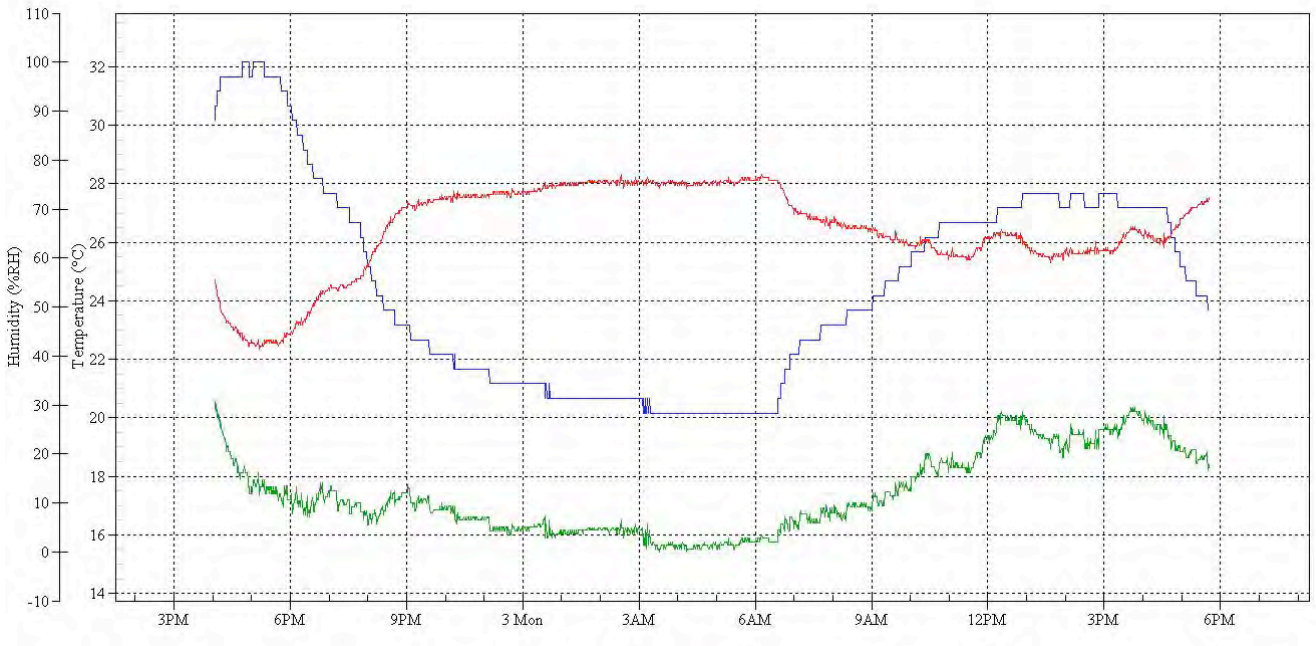



Fig. 8

Very high ambient humidity readings were again recorded. These rose during the night to attain approximately 75% while temperatures fell to approximately 20 ˚C. This is a very unsatisfactory environment for any Mediterranean or semi-arid habitat tropical tortoise. While the temperature is perfectly acceptable taken in isolation, combined with humidity levels as high at 75% it is the kind of environment that has long been associated with high levels of respiratory disease.

The final sensor which was positioned in the substrate at the basking site (Fig 9) recorded the (by now) expected dangerously high surface temperature in excess of 50 ˚C.

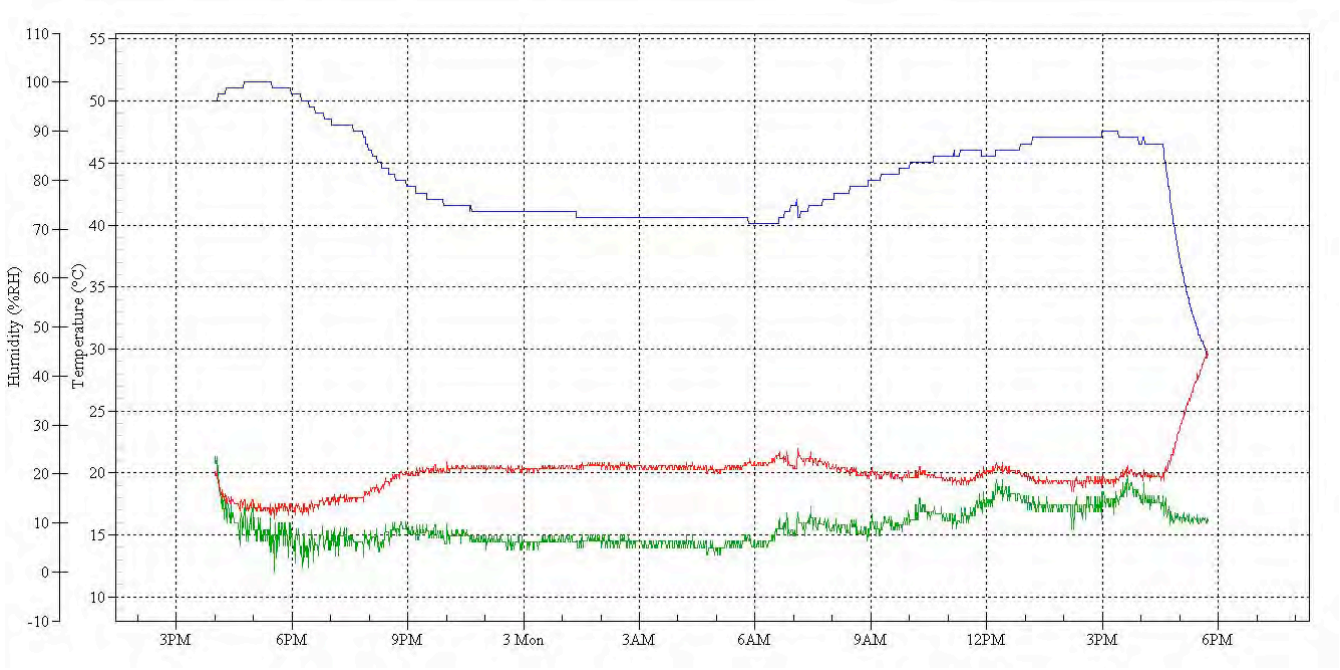



Fig. 9

It also revealed that at this end of the tank, substrate humidity remained in the region of 20% while surface temperatures varied from approximately 52˚C to 40 ˚C even at 3.00 a.m.

We feel very strongly that when used with the ‘moist’ forest substrate supplied, the environment created is completely unsuited to the maintenance of Mediterranean tortoises. The humidity levels in the ‘humid’ hide and in the ‘forest’ substrate itself are far too high for any semi-arid or arid habitat species. There is also a severe ‘chilling’ effect due to continual evaporation. We can only describe the conditions generated within this vivarium as extreme. It is either too hot, too dry, or too cold and too wet. We found it entirely impossible to create an acceptable habitat for any tortoise within this vivarium. As these tests progressed it became clear to us why we continue to receive so many anecdotal reports of sick, deformed and dead tortoises that have been maintained in units of this type.

We decided, however, to make one final attempt to mitigate the worst effects of the “forest” substrate. When used as directed in the instructions, it may be acceptable for very high humidity species or for amphibians. For Mediterranean tortoises, however, it is far too wet and causes the humidity to reach excessive levels. We first needed to dry it further. This we did by baking it on trays in a fan assisted oven at 230 ˚C until a sample produced a

humidity level of approximately 55% at 22 ˚C in a sealed container. Subjectively, the substrate now felt “very dry”. This was a laborious process that took several hours. The material appears to be capable of absorbing approximately 7-8 times its own volume of fluid when fully hydrated. When dry, that volume also reduces accordingly. We were left with a relatively thin layer of substrate when distributed over the vivarium floor. It measured approximately 1 cm deep. We pre-heated the vivarium and the sensor to 33 ˚C and then added the substrate. We positioned a sensor within the substrate to monitor the results over several hours (Fig 10).

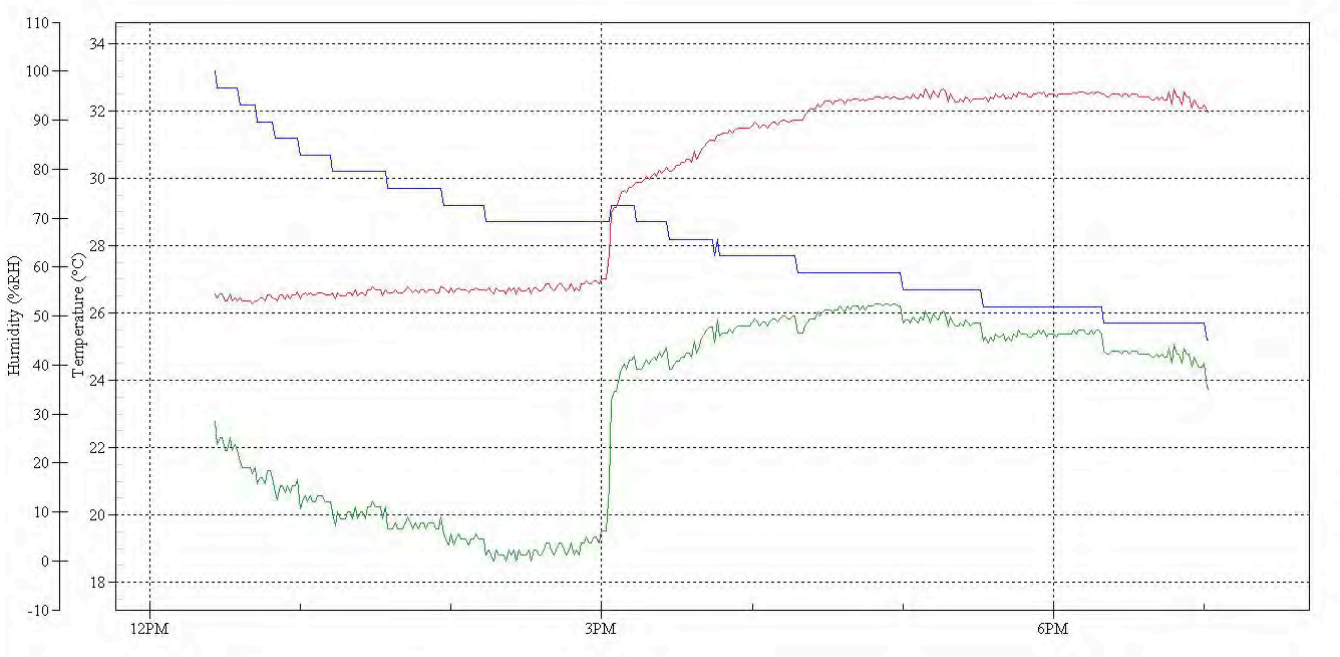



Fig. 10

There was an immediate gradual reduction in temperature, which we attribute to evaporative cooling. At 3.00 p.m. we lightly sprayed the substrate with a hand sprayer, (delivering exactly 15 ml of water in total) as it did feel very dry indeed, and the instructions do suggest that it should be “slightly humid”. We attempted to achieve this. Instantly the temperature began to fall further, and the humidity began to rise rapidly. Within 20 minutes it rose from 55% to over 70%. Within an hour it stood at approximately 85% and peaked at approximately 94%.

This confirmed our opinion that this substrate is completely unsuitable for use with Mediterranean tortoises. It retains far too much water, and then evaporates it into the atmosphere far too readily. The same effect would occur following a tortoise urinating. This substrate would absorb it like a sponge, and then evaporate it rapidly into the atmosphere causing a sudden and massive peak in relative humidity accompanied by a simultaneous drop in temperature. These are conditions that could almost be designed to cause respiratory disease in these species in our experience.

It only remained to determine what UV-B levels were available within the unit. With the supplied lamp the answer is zero. It is merely a standard incandescent spot lamp with a trace of blue dye to approximate daylight. Many keepers may decide to add a UV-B producing lamp, however, and indeed this is suggested in the instruction sheet. We tested the vivarium with two popular types, a new 100 watt T-Rex Active UV Heat flood lamp, and a Geko brand 24” 18 watt 10% UVB fluorescent tube.

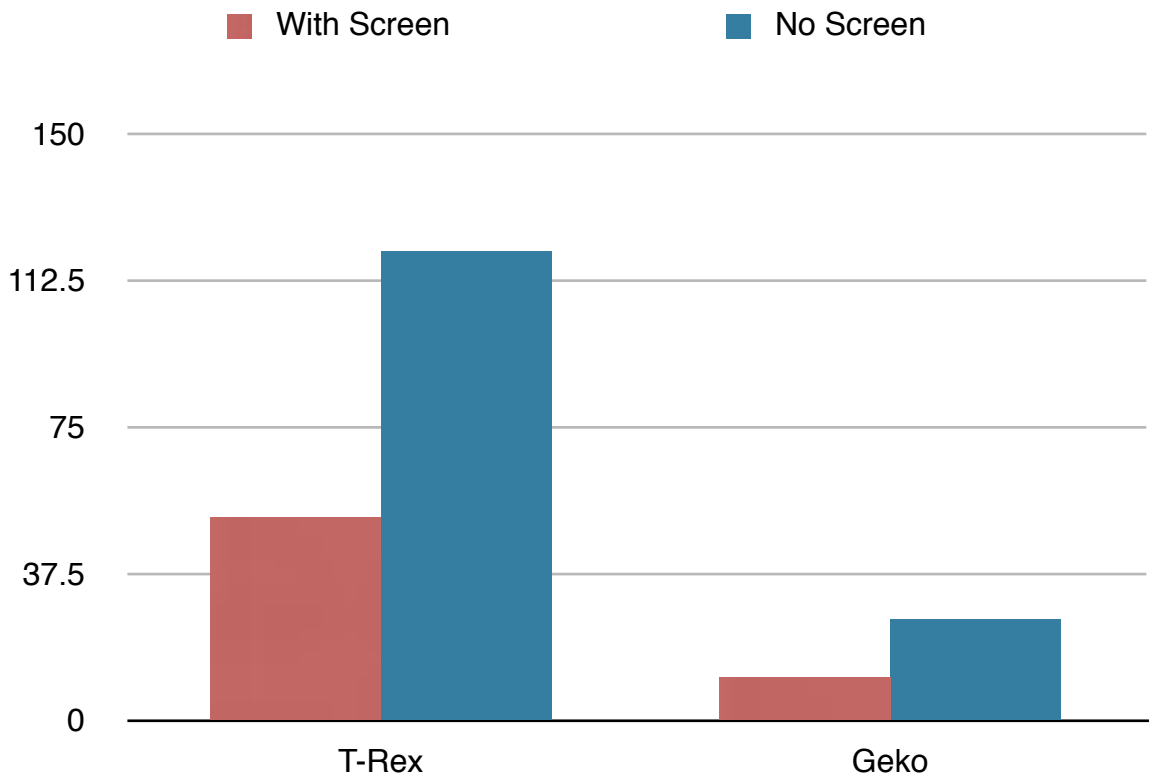
This was a relatively simple test. We positioned a Solartech, Inc. Solar Meter 6.2 UV-B within the vivarium with the sensor 35 cm from the top of the unit. We sited the lamps so that they would be at the same height as the screen top. We took two measurements for each lamp. One with the screen removed and one with the screen in place. Both lamps were allowed to stabilise for 10 minutes before the measurements were recorded.

**T-Rex 100 watt Active UV Heat**

Without screen: 120 $\mu$w per sq. cm
With screen : 52 $\mu$w per sq. cm

**Geko 24" 18 watt 10% fluorescent tube**

Without screen: 26 $\mu$w per sq. cm
With screen : 11 $\mu$w per sq. cm




These results indicate a very significant reduction in UV-B when the screen is in place. This reduction is not mentioned anywhere in the supplied literature. The scale of the reduction is such that an acceptable level of UV-B is never achieved for *Testudo* species (where a range of 75-200 $\mu$w per sq. cm is suggested). The tube would need to be used at a distance of no more than 12 cm to achieve useful levels. This is precluded by the overall design of the vivarium which provides no means of using the lamps with the screen removed.

Fig. 11 *The two substrates supplied with the vivarium*


Fig. 12 *Temperatures in excess of 50 ˚C were regularly measured in the substrate.*


Fig. 13 *The compressed "forest" area substrate. This proved to be problematic.*


Fig. 14 *A wide range of devices were used to record the vivarium environment.*

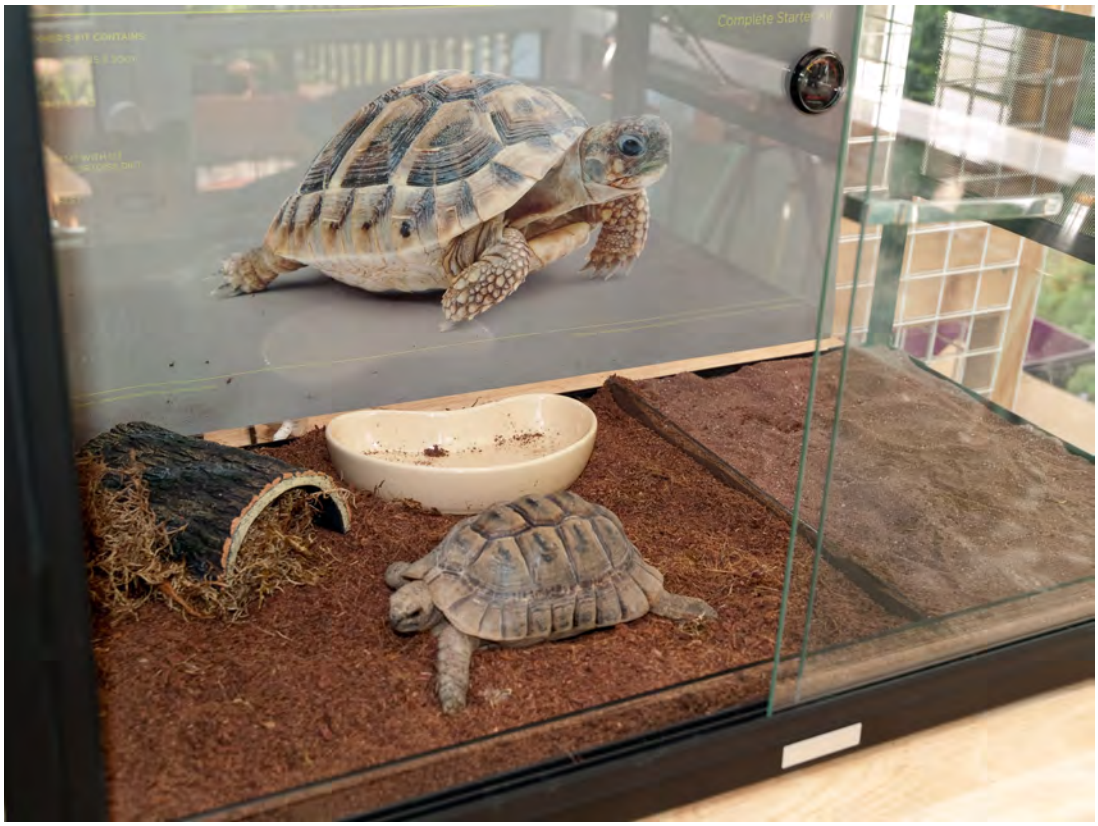


Fig. 15 *A 15 cm carapace length tortoise in the unit. Is this really acceptable? The Tortoise Trust questions whether housing of this size is suitable (or even lawful), as full time accommodation for an animal that normally requires a very large outdoor area.*

**Conclusions and key recommendations:**

•The supplied basking lamp is under powered and is incapable of producing an adequate basking temperature (an absolute minimum of 30 ˚C) at the basking site unaided at average ambient room temperatures. The fact that the height of the lamp cannot be adjusted, and that the fine mesh grill also blocks and dissipates both light and heat contributes to this very serious failure.

•The ambient room (background) temperature needed to be elevated to 26 C before a temperature of 30 ˚C at the basking site could be achieved. This is unrealistically high and is far above the level maintained in an average house (21 ˚C or 70 ˚F). Extended trials with this vivarium suggest to us that as supplied, it is capable of producing a basking temperature of approximately 5 ˚C above ambient at best.

•The supplied basking lamp emits zero UV-B. The tortoise is entirely dependent upon sufficiently regular use of the oral calcium and D3 supplement included. If a lamp that does emit UV-B is substituted (as supplied the Jon Coote Advanced Tortoise Kit) much of the benefit will be wasted as the fine mesh screen blocks most of the UV-B generated. In our opinion this is a serious design defect.

•The supplied heat pad is under powered (12 watts), and is too small, to provide adequate levels of background heat within the vivarium. In tests conducted overnight, average air temperatures within the unit fell to ambient with the heater in both rear wall and under floor modes. It is, however, capable of producing a very localised extreme ‘hot spot’ when used in under-tank mode with a thin substrate covering, of such a level as to cause severe

thermal burns (up to 53 ˚C). No thermostat is provided. When used in under-tank mode without a thermostat heat mats are intrinsically dangerous. The practice of relying upon ventral heat with chelonia is questioned by leading veterinary experts.

•The two small plastic thermometers supplied are inadequate to gauge the actual conditions within the vivarium. They are of very poor accuracy and when used as directed produce grossly misleading results. They do not, for example, measure the actual basking site or substrate temperatures. When a potentially fatal substrate temperature of 53 ˚C was recorded in these tests, the supplied thermometers indicated that the basking site end of the tank was only 30 ˚C. This could easily mislead a novice user. All vivaria should be checked regularly using at least a reliable contact thermometer to establish the gradients obtained and minimum-maximum temperatures at all basking positions and retreat sites. We recommend that if possible, a non-contact Infra-Red thermometer should be used in addition, together with a reliable hygrometer to establish the levels of humidity within the environment. Such routine checking will quickly reveal problems and will help to prevent injury and death.

•The lack of space and poor ventilation of the unit prevents an adequate thermal gradient forming. In our tests, differentials between the “hot” and “cool” ends of the tank as low as 1.5 C˚ were recorded. **This is completely unacceptable.** It is, however, characteristic and typical of all small glass tank type vivarium enclosures. They are simply not large enough to allow a useful gradient to form.

•The unit is said to be suitable for Mediterranean tortoises, African Spurred tortoises (*Geochelone sulcata*) and Horsfield’s tortoises (*Testudo horsfieldii*) up to a straight line carapace of 150 mm (7”). The instructions supplied fail to even mention the requirement for adequate outdoor housing for any of these species, and instead suggest that “room sized accommodation may subsequently be required for African Spurred tortoises for example”. In our opinion, the impression is clearly given that exclusively indoor accommodation is acceptable for all of these species. This is not the case and is seriously misleading. Further, we feel that given the units very restricted floor area (0.36 sq. m. or 3.87 sq. feet) the claim that it is suitable full-time living accommodation for a tortoise of up 150 mm or 7” carapace length is not only incorrect but is positively inhumane and to keep a tortoise so confined is quite probably unlawful under the Animal Welfare Act (2006) which makes it a duty to provide “suitable” accommodation. The many environmental failings noted here also, in our opinion, are so serious that any tortoise confined within it is not adequately protected from injury (the excessive substrate temperatures recorded) and that the incorrect temperatures ranges, poor gradients and humidity problems recorded here also place this product in probable breach of the requirements relating to a “suitable environment” and “need to be able to exhibit normal behaviour patterns” (e.g., thermoregulation) as specified by the Act.

•The substrate supplied is, in our opinion, entirely unfit for purpose. The problems with securing a satisfactory and safe level of humidity are obvious. The recommendation that this very small quantity of substrate should be changed only “every six months”, even in the case of a 150 mm or 7” tortoise, is also completely unacceptable and will invariably lead to severe problems with bacterial and fungal contamination and consequently to high levels of disease.

•Contaminated substrates are regularly implicated in skin and shell disease in chelonia, and also in respiratory diseases of both fungal and bacterial origins (Gardner and

Oberdorster, 2005). A small volume of substrate like this would, in our opinion, need to be changed at least once a week.

•Although this report examined the product of one particular manufacturer, it is our opinion that all “glass tank” vivaria of a similar size and design will invariably produce a very similar performance. The problems noted are largely an unavoidable result of this small, enclosed design.

**We would urge all responsible retailers to cease recommending units of this general size and design (enclosed glass vivarium tanks) for use with terrestrial tortoises. Our recommendation is for units with substantially more floor space, with much increased airflow and with improved temperature gradients, and which provide safe and effective basking facilities. It should be stressed to all purchasers that indoor vivaria are only a partial solution to the accommodation needs of tortoises, and that additional spacious outdoor housing is also essential on both environmental and welfare grounds.**

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