Health and Hibernation of Freshwater Turtles

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Abstract

This paper started as a set of notes about my North American freshwater turtles which I keep outside in the UK and was originally intended for personal use, soon I realised that it was just a start.

In our field, knowledge concerning (turtle) hibernation is still developing, so the original words have been revisited often. Recent winters have offered us extremes in weather and whilst they have given us challenges in the husbandry of our animals, they have also offered us an opportunity to learn. Over time I have been able to capture opinions of many experienced keepers and combined with an ever-increasing web sourced knowledge base, I have distilled the many snippets of information and technical papers into one decanter.

This paper touches upon the health prerequisites for overwintering and explores causes for high mortality in animals introduced into outdoor enclosures.

The paper recognised and debates that many species have different overwintering strategies under water and above ground including the ability to withstand some degrees of frost.

Habitat considerations are also touched upon with some suggestions of what could be offered in the UK and northern Europe.

Introduction

In our field, knowledge concerning turtle hibernation is still quite basic but the internet is slowly enabling knowledge exchange between the academic world and the hobbyist world – this is happening frustratingly slowly.

Very few books available to the chelonian hobbyist discus the hibernation challenge at any length. Standard methods for hibernation are sometimes offered and these may be based on experience or sometimes on hearsay. Often advice is offered based on what was presented in a paper maybe years ago and taken as dogma and as being always true for all species in all circumstances.

My own problem has been that some papers could be 20 or 30 years old and have been overtaken by newer research – sometimes by the same person.

When I started trying to understand why I was experiencing specific mortality patterns, papers were discovered that shed light and I started compiling an explanation. Much of my data is based on papers from Donald Jackson Professor Emeritus of Medical Science at Brown University and from many of his students who also published related studies. To my chagrin he retired but he did publish *Life in a Shell* in 2011. The book encapsulated his work in a non-technical way such that the hobbyist can find relevance to turtle husbandry.

Latterly my own observation of animal behaviour over the winter periods have highlighted that advice from hobbyists is often based on experience of smaller enclosures and that given larger set-ups – behaviour changes.

It is hoped that this paper asks more questions which when answered will add to our understanding of keeping temperate climate turtles outside.

A male *Trachemys scripta* just out, catching early spring sun on 23rd February 2012. Somerset, England.

Hibernation definition

In his paper on hibernation of Horned lizards W. Mayhew (1965), noted in his abstract...
The term brumation is proposed to indicate winter dormancy in ectothermic vertebrates that demonstrate physiological changes which are independent of body temperature....... it's a term that has caught on and has been a cause for debate ever since.
The argument is better outlined in an article in the Obligate Scientist *Ref.*[13] and concludes that the use of "*hibernation*" is appropriate 99% of the time.
Jackson in his book at *Ref.*[6] uses the word "*hibernation*" universally and that's good enough for me and this article.

Health

A successful hibernation has a prerequisite that the health of an animal is at 100%, so let's start with that:

Imported captive bred animals have never had to go through a natural selection process as they would in the wild. Contrary to popular opinion, breeders are meticulous with their breeding regime and a very high proportion of their hatchlings survive. Yet in the wild only a small percentage of all eggs laid become hatchlings as predation by raccoons, skunks and humans take its toll. Once hatched they then run the gauntlet of other predators, including alligators, otters, fish, birds and of course again humans. Any animal vaguely unfit is removed by nature; this is not the case in the turtle farms.
During rearing by turtle farms, neonates will have been kept in clinical conditions with reduced contact with natural pathogens and with protection offered by antibiotics and modern drugs so little natural immunity will have been developed. On a recent visit to a farm that breeds fish for the angling community I noted that breeding is initially conducted under the most stringent

clinical conditions but then as the fry grow, they are exposed gradually to water of increasing natural content. The view at the farm was that if the fry were suddenly and directly exposed to the "wild water", mortality rates would be significantly higher.

The young animals in nature have specific and balanced dietary needs along with the availability of natural sunlight and clean water. All too frequently newly acquired animals are kept and fed inadequately; the result is a weak animal or an animal that has grown unnaturally, often with a deformed shell. If the turtles' body or organs have not developed properly then it simply will not have all the tools to see it through hibernation as we shall see later.

I was fortunate enough to have visited Elmar Meier in Muenster Zoo and part of the discussion centred upon stress and the profound effect it had on the immune system; Kevin Eatwell at Edinburgh Vet School echoed him in another discussion. This part of husbandry gets too little attention but the reader should be in no doubt that a stressed animal is more susceptible to falling sick. Stress can be caused by physical health issues as well as environmental issues and indeed psychological ones *Ref.*[15]. When an indoor animal is introduced into the "wild" of an outdoor pond a number of stress factors will kick in which may manifest in serious stress related issues of one form or another.

- Some species or individuals, when introduced into a totally new environment can take months to settle down and so the animal may not come into condition in time for hibernation. In addition, blood cell count, antibody production and general immunity will also be depressed.
- It will probably be colder outside than their indoor tank so appetite will be depressed.
- The feeding regime will be different so intake will be reduced – the food may not even be recognised. Hunger will cause more stress.
- The indoor photo period may well be different to that outside and animals can take a while to get used to the new daylight hours.
- I had an animal that took two years to get used to the outdoor space having been cooped up in a small box; he was too scared to come out and eat!

Oxygen uptake under water

Most turtles are good at extra-pulmonary (without use of lungs) oxygen uptake and it is commonly quoted that the principal method of oxygen exchange is via the cloacal (vent) and/or buccopharyngeal (throat) pumping. This is a truth for some animals under some conditions.

Diffusion through the skin is a most significant oxygen supply mechanism for the species of turtle we are most likely to encounter (*Emydidae*). Jackson *Ref.*[6] *Ref.*[7] has proposed, with some experimental evidence for Painted turtles (*C.p.belli*), that under the lowest metabolic rates, water exchange in the cloaca does not happen but that the majority of oxygen uptake is through the skin and is sufficient to sustain the animal in water that has good oxygen content. Upon reflection this makes absolute sense as to pump water through the cloaca takes energy and for the longer winter durations every scrap of energy must be saved. In addition, why pump the cloaca in anoxic water where there is no oxygen – so no need to develop the capability.

Some statistics for extra-pulmonary uptake show the variation out there. Please note that some (most) of these animals do not hibernate so their extra-pulmonary strategy exists for extending their time under water and will be energy consuming. *Ref.*[6], *Ref.*[7] and *Ref.*[17].

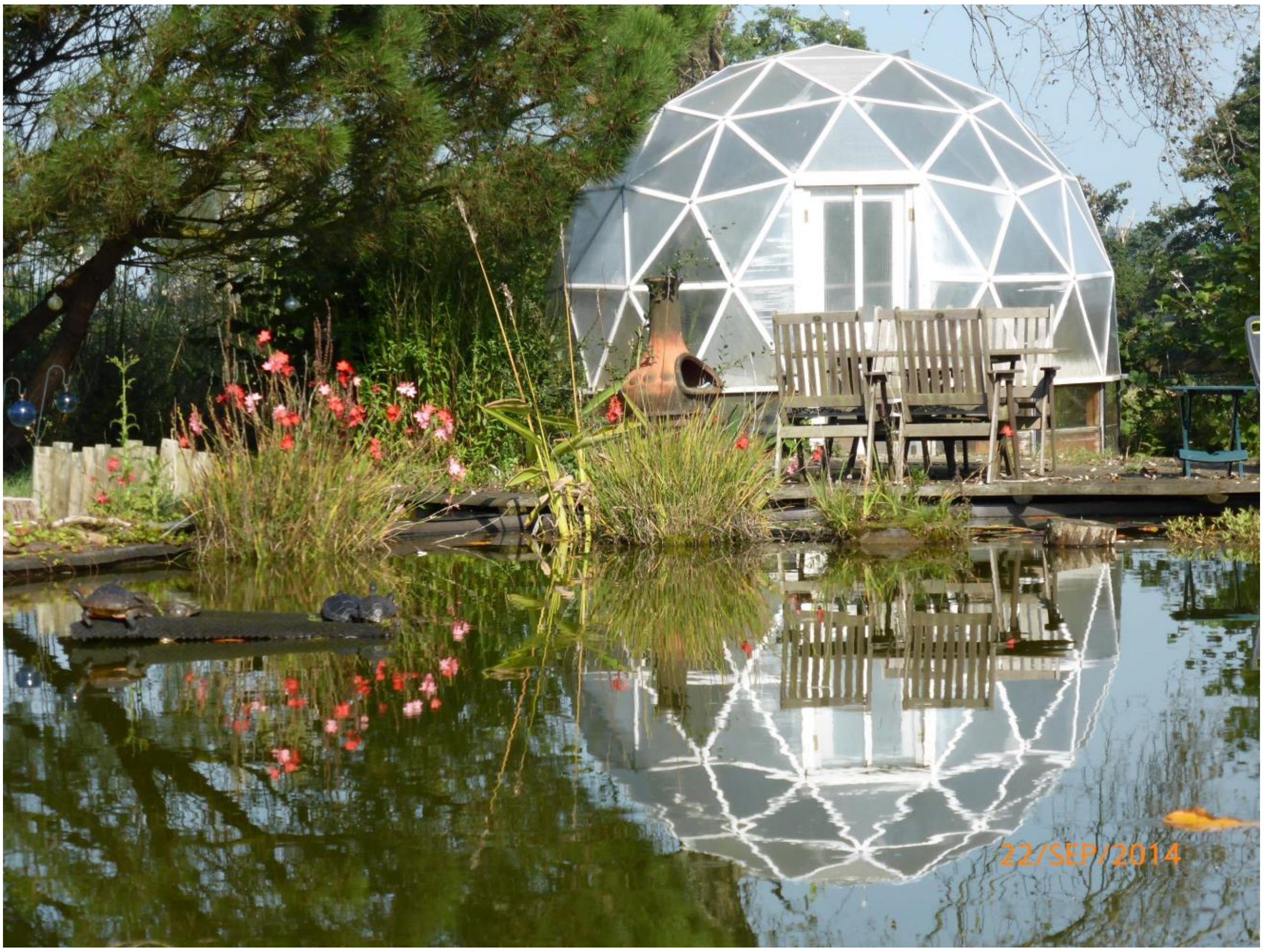
Elseya latisternum
49% Buccopharyngeal cavity
33% Cloacal bursae
18% skin

Podocnemys species
90% Cloacal bursae

Sternotherus species
30% Buccopharyngeal cavity
70% skin

Chrysemys and Trachemys species
100% skin

It does seem that nature has evolved the most effective and appropriate way for our turtles to gain extra-pulmonary oxygen that varies with species, size, sex, age, climate, environment, oxygen levels and temperature.



The 4m turtle dome and one of my ponds

Hibernation Overview

A turtles' capability to survive under water for periods of time including months of hibernation is just fantastic and it's worth having a look at some of the tools they have for achieving that.

1) Turtles and some other reptiles have a lung capacity significantly greater when compared to mammals, so can hold more air/oxygen. They also have less than 10% of our metabolic rate, so they use less oxygen; this means that the turtles' capacity to sustain themselves with air carried oxygen could be up to 100 times that of a warm-blooded animal. In addition, they don't have to cope with the regular breathing in order to keep warm. They only breathe when they have to *Ref.*[17]; in cold water when they are torpid with low metabolic rates their need for oxygen is massively reduced. Jackson once thought whilst testing cold water survival that his subject was

dead because the heart beat monitor showed nothing, however, to his surprise, after 10 minutes, he saw a movement on his test equipment indicating life. *Ref.*[6]

During dormancy blood is pumped sparingly, just enough to keep the brain alive and often every other non-essential organ function is turned down.

2) Turtles have a liver that forms a significant portion of body mass, this along with body fluids and muscle tissue stores huge quantities of glycogen which is used as an energy reserve for the winter. It's commonly thought that fat is the main energy store but fat cannot be metabolised without oxygen Ref.[6] i.e. in anoxic conditions. However, fat is stored and can be used when oxygen is available. ATP often cited in papers, is a chemical compound used by cells to store energy and release the energy in active processes but it is not good for storing large amount of energy for an extended period of time; it is derived from glycogen. Glycogen is the form in which glucose is stored in the body; it is a carbohydrate and forms a keystone in this discussion.

3) Turtles have other adaptations and, in his book, Jackson *Ref.*[6] talks about the turtle heart having an extra valve with the capability to divert unwanted blood flow away from the lungs once lung oxygen is depleted.

4) Jackson has shown that with lower water temperatures, less energy is consumed, thus less oxygen is required. This is important for the keeper to understand as there is a significant difference of energy usage between 10^0C and 3^0C. This is especially important for the pond dwellers. It will be remembered that up in the American north, winters can last many months so that any energy saved can be reserved for the first days of spring. In addition, in anoxic conditions, glycogen is used significantly faster. Stories are often told about turtles moving about under the ice, now we have a reason – they are seeking cooler or better oxygenated water. As I write this in December my hibernating turtles *Chrysemys picta* and *Emys orbicularis* are moving about the bottom of my ponds with water at 6^0C.

5) With deep still water, anoxic layers can form in the pond. This can happen when bacteria oxidise detritus in the pond using oxygen at a greater rate than plants and surface gas exchange can replace. In winter when ice forms it prevents surface gas exchange and matters are made worse when snow settles, as it stops the light getting to the plants, thus they stop producing oxygen by photo synthesis but they (plants) continue to use it for respiration. Very quickly the water is depleted of oxygen and becomes anoxic.

6) The effects of oxygen deprivation are similar with turtles and humans but of course turtles have a significantly greater capacity to resist hypoxia *Ref.*[17]. Lack of oxygen or glycogen impairs brain activity significantly; that's why pilots need oxygen masks at high altitudes. The burn of glycogen without oxygen forms lactic acid in the blood, in marathon runners this contributes to seizing up the muscles and is called acidosis, the same acidosis will kill a turtle in extreme cases. It can be seen that if an anoxia incapable turtle is caught in an oxygen deprived pond and is unable to get to the surface air easily, it is seriously at risk.

7) Many turtles, in particular the pond turtles, have the ability to utilise the calcium carbonate ($CaCO_3$) within the shell. Their shell is about 40% of body mass and it is used to buffer the lactic acid in the blood and raise the pH thus reducing the effect of acidosis *Ref.*[6]. In addition, the shell can sequester some of the lactic acid and store it for disposal when oxygen becomes available again after the winter thaw.

8) The build-up of lactic acid can take hours, days or weeks depending on the temperature and oxygen levels in the water *Ref.*[1]. The lactic acid in the blood and in the shell can take equally long to dispose of once conditions are better in spring. The calcium used must also be replaced, so for females about to produce eggs this is a particularly hard time.

10) Upon rereading Jacksons work and the works of others, it is clear that the age (and maybe the sex of animals) also has a part to play in the overwintering strategy. The skin surface to animal

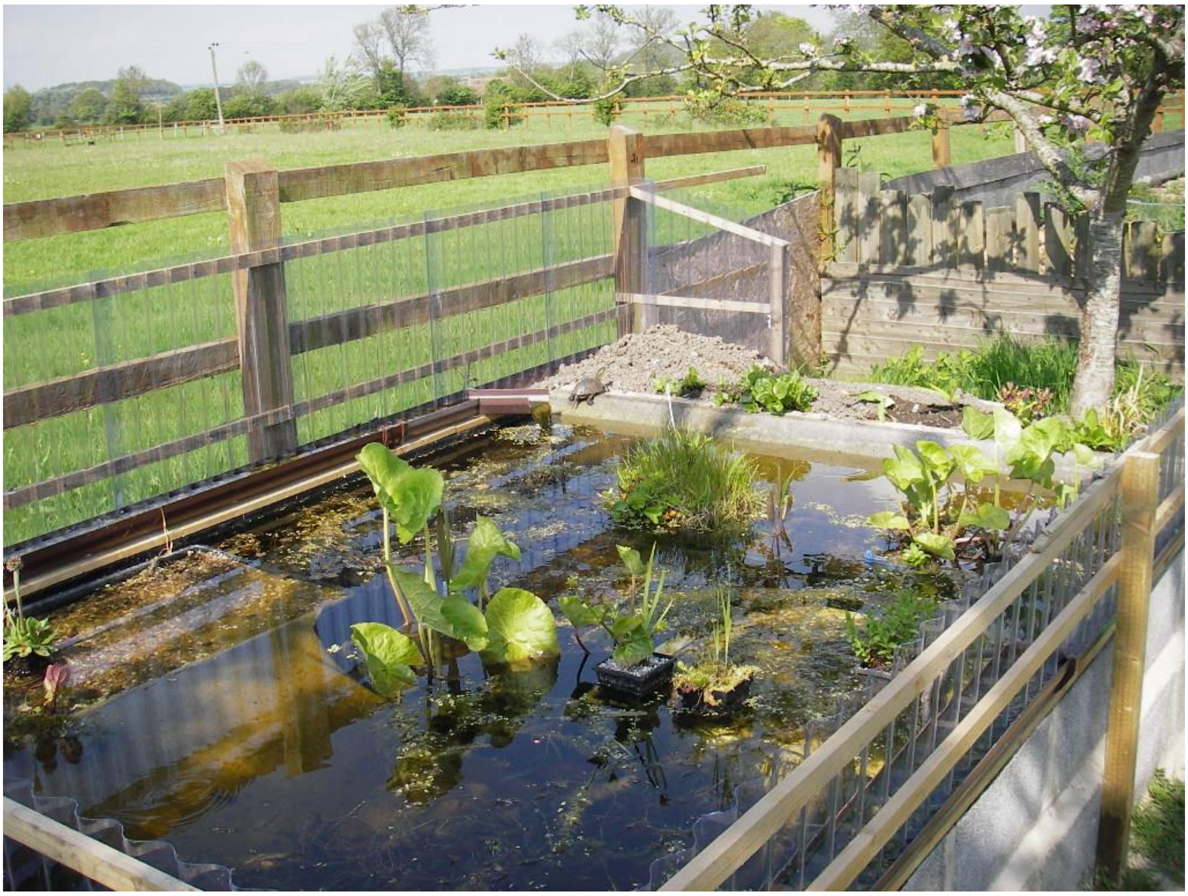
volume ratio plays a part here and the same law applies to the capability of storing/ buffering lactic acid.

Males of some species such as the Maps are considerably smaller than the females thus their skin area to volume ratio is better, so offering a better extra-pulmonary capacity.
A larger animal will have a larger shell thus potentially an improved capacity for lactic acid buffering and sequestration.

Reese *Ref.*[14] confirms that some youngsters are less capable of overwintering than adults; this is due to a combination of the above factors. It is also probably the reason why in the first year overwintering sometimes occurs in the nest site. A newly hatched animal will have reduced bone structure and hence no available carbonate buffer for the lactic acid produced in anoxic conditions (remember that hatchlings come with a cartilage structure that ossifies as the animal grows). Many breeders keep their hatchling indoors over the first few winters; this strategy may work because it prevents the neonates entering an anoxic condition. . Rogner *Ref.*[10] states that in practice he overwinters his yearling *Emys orbicularis* indoors with some success.

My own experience with Spotted turtles and Painted turtles (C*lemmys and Chrysemys*) confirms the concept. I hibernate all my hatchlings in outdoor enclosures and even if released in August the youngsters find their way out and hide under bark and rocks which I have now learned to leave for them. I cover the whole are in and insulating layer of leaves for the winter. Sometimes they get back in to the water to rehydrate.

After sharing this view with other outdoor keepers, it seems that land usage by youngsters to be much more prevalent than is mentioned in care sheets. Certainly, for these two species I strongly recommend a land area covered in bark and leaves that would offer winter hibernation opportunities.



The *Emys orbicularis* pond

Freeze Tolerance

Popular TV (David Attenborough's *Life in Cold Blood*) has shown us how turtles can survive freezing; the image being a generic one giving the public a misconception that all turtles can survive frost – that is not the case. Mostly turtles try and elude the ice but, in some instances, strategies have had to be adopted to manage it.

Frost kills through the propagation of ice crystals which when grown through cell structure cause irreparable cell damage and in the extreme - death. Constanzo and Baker have done much to explore this area and their papers *Ref.*[2,] *Ref.*[4] and *Ref.*[5] cover some interesting ground. The authors on this subject have a spread of opinions which makes for interesting research.

Costanzo Ref.[5] shows that *Sternotherous odoratus, Graptemys geographica*, and *Trachemys scripta* have poor freezing capability, that *Chelydra serpentina* is intermediate but that *Emydoidea blandingii, Chrysemys picta belli, C.p.marginata, Malaclemys terrapin, Terrapene ornata* and *T. carolina* have good freeze tolerance. This is a most interesting finding as the grouping aligns with the riverine and anoxic pond dweller separation described below. The star of the TV programme showing freeze survival was in fact a *Chrysemys picta.*

In Para 10 above, mention is made that hatchlings do not have the calcium carbonate packaging to serve as a lactic acid buffer; these animals must survive winter above anoxic water. Where they live, the winters are long and very cold with the frost line often reaching well below ground.

There are a number of strategies used to survive non-aquatic hibernation.

The location and soil structure play a part; the soil can provide insulation and delay the onset of ice. Frost is not the only threat here; Hatchlings are apparently unable to absorb water from their surroundings but the surroundings could cause desiccation. This interesting area is little studied or reported.

Chrysemys picta egg chambers are not too deep and are often above the frost line especially in times when snow cover is poor. Cryoprotection is required and is gained through the use of antifreeze (glycogen) which reduces the freezing point. Constanzo in *Ref.*[5] also recognises that animals in this group have larger supplies of yolk (and stores of lipids acting as anti-freeze) available to them at hatching than those that hibernate aquatically.

Some animals are capable of undergoing super cooling i.e. reducing their bodies' ability to allow crystallisation or inoculation of ice crystals to occur within the body. This includes emptying their bowels, reducing water content and even the location of limbs and skin surface finish.

In practice it seems that turtles use a combination of all of the above strategies.

Feeding

I was always under the impression that turtles were unable to eat until the water temperatures reached about 15^{0}c. In February 2013 the turtles that were in my dome came out of hibernation early because of the warmer air temperatures, as they were moving about, I thought I might try feeding them a meal worm. 7th February is recorded in my diary and although water was below 10^{0}C; air temps did reach 29^{0}C. What surprised me was that all of them ate well! The conclusion is that if the animals are sunbathing and getting their body temperature up, it is worth trying some food no matter how cold it is outside and as a bonus it takes away their reliance on their glycogen stores.

Breeding

It is sometimes stated that turtles need to be hibernated to breed successfully; however there seems to be little hard data on the subject. I do however have observations from a very experienced breeder in USA, Chris Leone, that the Spotted turtle (*Clemmys guttata)* will produce multiple clutches without hibernation and that in contrast the Wood turtle (*Glyptemys insculpta*) and Blandings turtle (*Emydoidea blandingii)* do need to be hibernated.

Daylight

For some time, I have been monitoring what triggers my animals into hibernation and I have noted that whilst animals will eat at low temperatures in the spring, that my animals have gone off their food by October despite the water still being warm. Monitoring barometric pressures seems to show no obvious correlation. The driver for hibernation, it seems is the recognizable reduction in daylight length around the equinox and the lower temperatures that come with it. Similarly, animals start moving again once the daylight time starts increasing perceptibly.

Habitat

Read any of David Carrols' books *Ref.*[3] – and it will be seen that his accounts of turtle migration as the seasons change are very telling. He talks of migration in spring to vernal ponds where there is plenty of easy food such as tadpoles. He talks of migration to breeding areas and of migration to other areas as food availability changes. In the wild they have to hunt for their food and learn where to find it with the seasons. Their willingness or even drive to travel and explore should be accommodated. It is noticeable in my naturalistic set-up that many animals are willing to get out of the pond and go hiking in autumn – presumably it is the instinct to travel to hibernacula.

The wild turtle may well have an internal map for the best hibernation location, sometimes this may be communal. When winter comes, captive turtles will not have a choice of location for their big sleep and the pond keeper must provide suitable hibernation conditions appropriate to the animal type kept. Most people keeping turtles in ponds in the UK will have the riverine type of turtle implying a need for well oxygenated water.

Edge in *Ref.*[8] identifies in a study of site locations, that sites with shallower water depths were preferred (between 40 and 120cm).

Matters are complicated for keepers because reference books are often out of date and misleading. My Spotted turtles (*Clemmys guttata*) are known to be more terrestrial but all the literature talks of their hibernation in water. Yet I have animals that have hibernated on land, the extent of this habit has varied with individual animals and with the weather. In 2012 I had a male Spotted turtle (*Clemmys guttata*) that spent the night under leaves and if it was nice, he came out, after a few days if he was dehydrated, he dipped in the water quickly then became a land animal again. In 2014 the same animal spent the autumn behaving similarly but disappeared under water for mid-winter then only to reappear under leaves in February. Many of my neonates hibernating for the first time outdoors hibernate under logs and leaves as described previously.

Similarly, writers suggest that the Wood turtle (*Glyptemys insculpta*) prefers river waters for hibernation and mine will sit in the pond waterfall enjoying the cold well oxygenated water stream during the year but a few hibernated in leaf litter. The complexity and variety of hibernation continues - I am noting that over the year's patterns change for some animals within the same environment. It could be animals establishing their preferences as in the case of the male Spotted turtle, it has taken a couple of years to get it optimised.

The riverine animals will take care that they have good oxygenated water if it is available to them but in the wild, they will also have to deal with water level changes. In the UK winter, we think floods, however in northern USA the depth of winter brings months of freezing temps often less than -10^{o}C for weeks and weeks. Rain does not fall; snow does, several feet in fact. This snow acts as an insulator from the severe weather above the water and ice layer. The temperatures in the water will be the same as we would find anywhere in Northern Europe. During the winter period the water levels often drop and air gaps develop between water and ice. Animals will take the opportunity to use airborne oxygen rather than water borne oxygen simply because it is more efficient. I have seen my animals sitting (hidden) near the surface and gently poke their noses up to get air.

Winter of 2011 was a nightmare for many of us in the UK that hibernated turtles outside. Whilst my pond dwellers all did well generally, my riverine species were hit very hard. The ice stayed for nearly a month and as I don't have a pump system the inevitable anoxic conditions overcame some of my animals - mostly the big Slider (*Trachemys*) females.

So finally, the habitat too, plays a part in the ability for the turtles to survive outside in the UK.

Considerations for the UK and Northern Europe

As keepers we must also remember that many tropical and subtropical turtle species have not evolved to survive colder seasonal temperatures and do not utilise hard hibernation as an over wintering strategy. In the cooler weather they just drift in and out of torpidity and in our climate, potentially die. There are also those marginal, temperate climate species that may cope with winters but are particularly challenged by the insipid British springs.

Over the years I have kept many American species outside and it seems that in my ponds that the Sliders do much less well than other species of turtle. Initially I thought it might just be the anoxia capability as many other keepers with a high flow water filter system seem to do well. Now some 18 years plus into keeping turtles outside, I am concluding that the Sliders (*Trachemys* group) really struggle in the British climate. Those that survive probably have a genetic background that originates from the northerly American states.

Jackson *Ref.*[6] indicates that northern variants of some species may have better overwintering capabilities than their southern cousins. A vital consideration therefore for those of us wanting to keep turtles outside is the confirmation that the subject species is at least suitable and that its genetic source is of a northern nature.

The turtles commonly available are mostly from North America and can be split into two groups for the purpose of this discussion; those that are riverine dwellers and those that are enclosed pond dwellers.

The Riverine Species hibernate in rivers with a frozen surface but the water continues to flow and is generally rich in dissolved oxygen throughout the year. In this group belong the Sliders (*Trachemys* sp.), the Cooters (*Pseudemys* sp.), the Map turtles (*Graptemys* sp.), the soft-shell turtles (*Apalone* sp), and Musk turtles (*Sternotherus* sp.). These animals often have good skin surface compared to their volume as well as cloacal (vent) and/or buccopharyngeal (throat) strategies. The prerequisite requirement for this group is well oxygenated water for overwintering.

Enclosed Pond dwellers predominately inhabit ponds that have no great moving water source and that get totally frozen over in the winter and have potential for becoming anoxic. The Pond dwellers include the Painted turtles (*Chrysemys* sp.), the Snapper (*Chelydra* sp.) and the Spotted turtle (*Clemmys* sp.). I believe that the European Emidid *Emys orbicularis* falls into this group but have found no supporting scholarly evidence; I have just my experience as a base for the assertion. This group seeks out the coldest water in order to reduce their metabolic rate in preference to higher oxygen levels.

It's an interesting thing that riverine species are particularly adept at extra-pulmonary oxygen intake but cannot cope well with water that is depleted of oxygen. A Slider can survive in anoxic water no more than about 10 days; Cooters are a bit better, so it varies from species to species. However, the Western Painted turtles can survive 150 days in anoxic water Jackson *Ref.*[6], *Ref.*[8].

So what do they need in outdoor situations?

As outlined above, turtles have many complex needs and just placing them in a pond does not mean it will be suitable. It is, unfortunately, an assumption commonly made.

A caution and to avoid disappointment; - A very large proportion of “rescued” animals that could be considered as suitable for an outdoor pond die when introduced outside. This is my experience and the experience of others and despite a properly considered introduction they die for all of the reasons noted under health above.

Turtles are ectothermic and need

1) Sunlight to provide ultra-violet A and B to help manage a number of important biological functions including the production of vitamin D3, so vital in replacement of used calcium and in preparation for egg laying.
2) Recently the Covid 19 pandemic has caused science to look at respiration and associated diseases in detail. A number of studies have shown that vitamin D3 is a key factor in helping the immune system fight respiration disease. Dr. John Campbell has an excellent video covering the evidence. RI is sometimes encountered in herpetology so appropriate Vit D3 levels should be a husbandry consideration. *Ref.*[20]
3) Bright visible light provides the stimuli through the lateral and parietal eyes that manages and controls the circadian cycle. *Ref.*[19]
   a. The parietal eye is a photosensitive organ just below the skin on some reptile heads and **regulates** serotonin and melatonin synthesis in the pineal gland. Both neuro-hormones modulate the reptilian immune system. The parietal eye also manages the circadian rhythm of the animal. The eye responds best to blue and green wavelengths
   b. The pineal gland underneath, below the skull, is most sensitive to the near infra-red wavelengths (600 – 750nm) and ties in with the NIR penetration of tissue at this wavelength. This is the site of serotonin and melatonin synthesis.
   c. Sunlight also acts as a bactericide/fungicide – it is so valuable to deal with post hibernation ailments such as fungal growth or sticky eyes.
   d. The production of dopamine is also associated with bright light it is related to the circadian cycle and stress level reduction. Ref.[21]
4) Irradiation from sunlight to raise their metabolic level in order to move and digest food. This temperature varies from animal to animal but 35^0C – 40^0C is a good generality and in a sheltered spot that temperature is easily achieved even in the UK and Europe. The sunlight component offering this heating effect is often described as Near Infra-Red and centres about the 800nm wavelength. It has the ability to penetrate surface tissue and offer health and healing benefits. It is particularly important to the recuperation process directly after hibernation. A tungsten halogen lamp provides the nearest equivalent to sunlight indoors. Measure its strength by using the back of your hand its warmth should be no more than a very gentle warmth. The dose here is important couple the tungsten lamp with a bright LED spot or halide lamp also to give the same gentle warmth. The two work together as the above paragraphs show.
5) I have encountered soft tissue infections after hibernation, often around the eyes. This is nearly always due to less than the cleanest water and sometimes stressful conditions. Whilst there are easily available medications available the most effective medication has always been sunlight or appropriate light as described above.
6) If the turtles have been hibernated outside in the cold, I have found minimal weight loss, one or two percent. However, if hibernated in conditions that are warmer, or there is insufficient humidity then weight loss can be greater. This is due to the greater use of glycogen reserves and simply, dehydration. Not all animals choose to hibernate in water. I provide additional opportunities by providing a pile of peat, dirt and leaves covered by bark strips. These I water during the winter.

These sunlight qualities (UV, bright visible light and Infra-Red) go hand in hand. Without sunlight they will simply not survive. Their pond therefore needs a basking area that has full sunlight for good portions of the day but especially around midday. The basking area should be private so they are not scared into the water frequently and a wind shelter will help also. They should be able to get into their basking area easily.

In discussions with other keepers it seems to me that those that have a filter with a waterfall output are generally successful with keeping Sliders (*Trachemys)* and this may also apply for the Maps (*Graptemys)* and Cooters (*Pseudemys)*.

The animals that I have had good success with are Painted turtles (*Chrysemys*) – all 4 subspecies, Spotted turtles (*Clemmys Guttata*), Cooters and River Cooters (*Pseudemys floridana* and *concinna*), False Map turtles (*Gramptemys pseudogeographica*) and of course our European Pond Turtle (*Emys orbicularis)*.

The pond should not be too deep, say less than 0.6m (2 feet). This depth allows sunlight to penetrate allowing plant oxygen generation. It also helps to reduce build the up of anoxic water layers by water circulation due to wind.

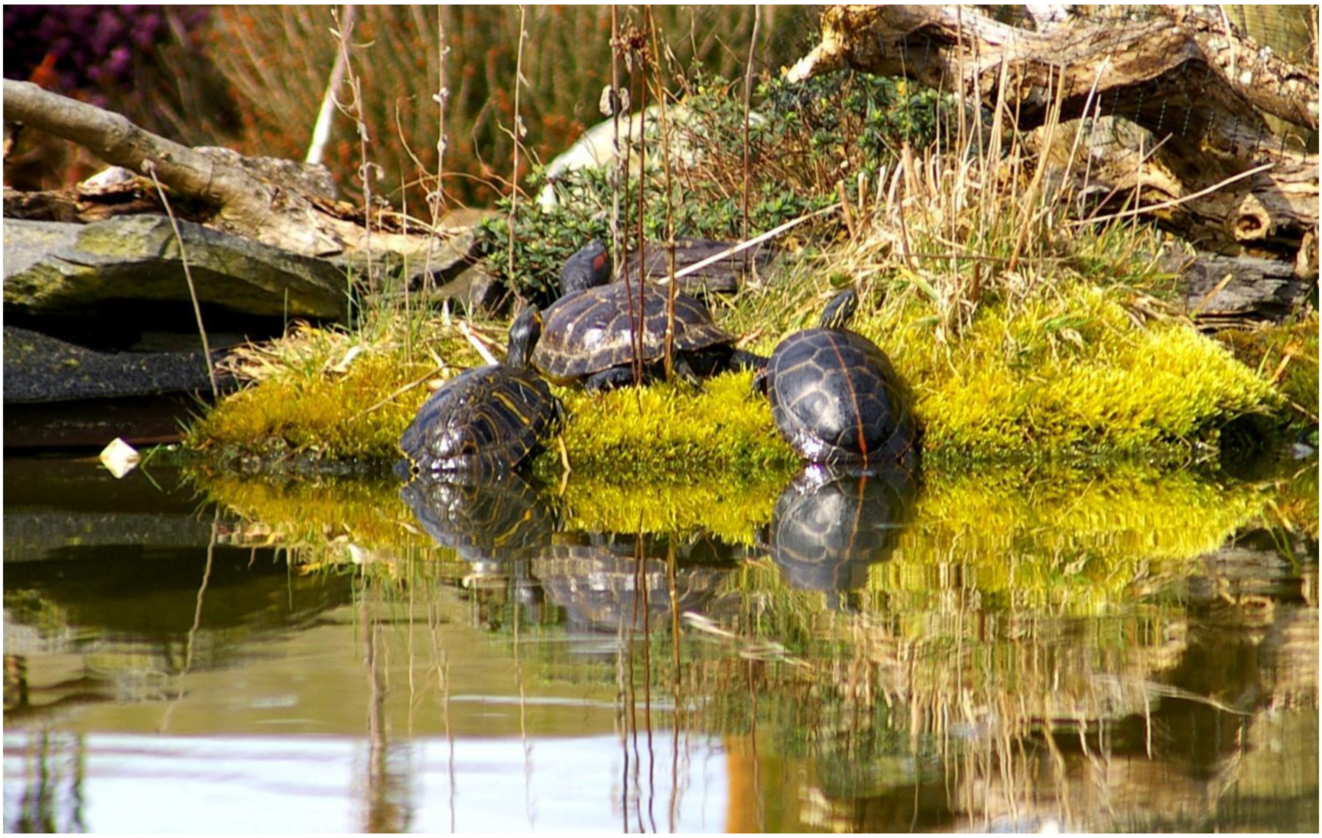
The pond should have sloping sides so that animals can move about and get to the surface easily if they are cold, stiff or in trouble through acidosis.

The pond should have as many oxygenating plants as possible. If snow falls, clear the ice above the plants and allow the sunlight back in.

In Conclusion

There is no doubt that many of the commonly imported turtles from the Northern American States can survive in outdoor ponds in the UK and Europe. This is confirmed by the many thousands that have survived since the original Ninja craze over 20 years ago. The most commonly released – the Sliders and the Cooters - are often from the warmer parts of the USA and may not be genetically disposed to the long winters and the cool summers in the UK and their mortality rate is high. Those that survive are a credit to Darwin and are probably from northern more robust genetic stock.

If an animal is healthy, is lucky with its genetic make-up and is provided with suitable conditions it will survive many years outdoors. I have animals that have been outside for over 15 years.



All the species emerge within a week of each other. 21st March 2010. Somerset England

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If you want to read more get "*Life in a shell"Ref.*[6] and "Year of the turtle" *Ref.*[3] first, both are excellent reads with good information presented well.

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More data will emerge adding to the story or I may have got it wrong, it will continue to evolve.