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Habitat use in basking Northern water (*Nerodia sipedon*) and Eastern garter (*Thamnophis sirtalis*) snakes in urban New Jersey

JOANNA BURGER burger@biology.rutgers.edu
CHRISTIAN JEITNER
Division of Life Sciences, 604 Allison Road, Rutgers University, Piscataway, NJ 08854-8082, USA; Consortium for Risk Evaluation with Stakeholder Participation, Environmental and Occupational Health Sciences Institute, Piscataway, NJ 08854, USA

HEATHER JENSEN, MEGAN FITZGERALD AND STACEY CARLUCCI
Division of Life Sciences, 604 Allison Road, Rutgers University, Piscataway, NJ 08854-8082, USA

SHEILA SHUKLA, SEAN BURKE AND ROBERT RAMOS
Division of Life Sciences, 604 Allison Road, Rutgers University, Piscataway, NJ 08854-8082, USA; Consortium for Risk Evaluation with Stakeholder Participation, Environmental and Occupational Health Sciences Institute, Piscataway, NJ 08854, USA

MICHAEL GOCHFELD
Consortium for Risk Evaluation with Stakeholder Participation, Environmental and Occupational Health Sciences Institute, Piscataway, NJ 08854, USA; Environmental and Occupational Health Sciences Institute, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ 08854, USA

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Abstract. The habitat use of basking northern water (*Nerodia sipedon*) and Eastern garter (*Thamnophis sirtalis*) snakes was examined along the Raritan Canal, an urbanized area of central New Jersey. There were significant differences between the two species with respect to cloud cover, canopy cover, and the distance to the path and the water, but not with respect to percent of the body exposed to the sun, and percent of the snake that was visible. Water snakes were more likely to bask on bushes, branches and logs than were garter snakes. Garter snakes basked when both the air and water temperature were lower than did water snakes. The lack of basking sites in the water suggests that those along shore are important, including the low hanging branches used by the watersnakes.

Keywords: water snakes, *Nerodia sipedon*, eastern garter snakes, *Thamnophis sirtalis*, basking, habitat, temperature

Introduction

Habitat selection is the choice of a suitable environment for a given behavior, from a variety of available choices. Microhabitat choice for a particular behavior, such as basking by poikilotherms, should be relatively plastic so that the animal can regulate temperature

appropriately, while remaining safe from predators. Tiebout and Cary (1987) considered space use to include home range, habitat, substrate, perch height, and exposure to sunlight. Other factors, such as predator avoidance also influence microhabitat selection (Robertson and Weatherhead, 1992). Considerable attention has been devoted to examining the role of microhabitat selection in snakes, particularly Northern water snakes (*Nerodia sipedon*), in both the laboratory and the field (Hebrard and Mushinsky, 1978; Justy and Mallory, 1985; Robertson and Weatherhead, 1992; Brown and Weatherhead, 2000). Most of this research has been conducted in swampy regions relatively far from habitation.

Water snakes living in a marshy habitat selected dead cattail clumps for basking (Tiebout and Cary, 1987) or the low branches of willow trees within the marsh (Weatherhead and Robertson, 1992). In general, water snakes selected sites far from the edge of banks, where they might be vulnerable to mammalian predators. Basking out in the open, away from banks, also maximizes the direct sun penetration since there is no canopy.

In the field, water snakes basked more frequently as the temperature of the air increased relative to the water (Robertson and Weatherhead, 1992), and were generally active from April to October even in the northern part of their range (King, 1986).

The relative increase in air temperature might be enhanced by the presence of direct sunlight. As with most reptiles, temperature affects most aspects of their behavior (Finkler and Claussen, 1999).

In this paper we examine habitat use during basking of Northern water snakes and Eastern garter snakes (*Thamnophis sirtalis*) inhabiting the Raritan Canal, which is located in an urbanized area of central New Jersey. There were no associated marshes, and there were no available basking sites except on or along the bank of the canal. Further, the available space between the bank and the canal was limited (2–4 m in width), suggesting that available options might be limited. Because the study was conducted in an urban area, habitat diversity and complexity was less than is usual for water snakes, and human intervention is greater. That is, the tow path is kept clear, the edges are mowed periodically, and basking logs are removed periodically from the canal itself. The Raritan Canal is thus a small, but more spartan laboratory than the two species are normally exposed to.

We wanted to examine whether there were habitat differences between the two species, whether they basked at different temperatures, and whether their choice of basking substrates differed from random. We were interested in the choices each snake made for a basking site, given the limited amount of habitat in an urbanized region. Snakes must make a trade-off between easy and rapid predator escape, and thermoregulatory constraints for basking (see Downes, 2001).

We made the following predictions:

1. Water snakes would remain closer to the canal than would garter snakes. The water provides an avenue of rapid escape for water snakes, while garter snakes usually go under vegetation when disturbed. Since water snakes are primarily aquatic (Robertson and Weatherhead, 1992), remaining close to the canal would provide a rapid avenue of escape.
2. Water snakes would select basking sites that were above the ground and exposed to the full sun, as suggested by the basking sites noted by Tiebout and Cary (1989).

3. Being mainly terrestrial, garter snakes would begin to bask when the air temperatures were lower than would water snakes. This is based on the observation of Robertson and Weatherhead (1992) that water snakes begin to bask when there is a greater temperature difference between the water and air temperature.
4. The lack of overhanging branches and logs, typically used by water snakes for basking in less urban environments, will results in these sites being preferred.

Methods

Observations were made from 14 May through 3 October 2001 while walking on the tow path (converted to a walking/bike path) along the Raritan Canal, which parallels the Raritan River from New Brunswick south to Blackwells Mills, New Jersey. The tow path is used extensively by walkers, bikers, naturalists, and joggers, although no motorized vehicles are allowed on the path. The canal and tow path are part of the Delaware and Raritan Canal State Park. Consecutive sections of the canal were walked to eliminate the possibility of sampling the same snakes. Most water snakes remain within about 250 m of their initial trap location (Mills *et al.*, 1995).

The bank of the canal is lined with tall deciduous trees of a large variety of species, and part of the bank is shaded at most times of day. The overall protocol was to walk at a constant speed along the canal looking for snakes. Information recorded for each snake located included: species, date, time of day, number of observers, air temperature at 50 cm above ground, water surface temperature, cloud cover, canopy cover over the initial location of the snake, amount of the snake exposed to the sun, percent of snake visible to the observer from 1 m away, substrate type, and distance the snake was from the path and from the water (both horizontally and vertically). Since there was a bank varying from about 50 to 150 cm along the canal, the snakes could be level with the water, higher on the bank, or in a branch or tree above the canal. Substrate types included fallen branches, live bushes, leaves, logs, trees/stumps, dirt or rocks. The snake's behavioral responses to our approach are discussed elsewhere (Burger, 2001).

We compared the substrate of the snakes to random locations by using the mean distance snakes were from the water, and generating a list of random numbers for the distance along the tow path. Nonparametric ANOVA, yielding a Wilcoxon X^2, were used to determine whether there were differences among variables as a function of species or substrates (SAS, 1995).

Results

There were some significant species differences in basking sites (Table 1). Water snakes were closer to water, and farther from the path, than garter snakes (figure 1), supporting prediction 1.

Both water and garter snakes were primarily basking on leaves on the ground (figure 2). More water snakes were on branches, and fewer were on bushes or dirt, compared to garter

Table 1. Comparison of physical habitat characteristics during sightings of Northern water (*Nerodia sipedon*) and Eastern garter snakes (*Thamnophis sirtalis*)

Species	Northern water snake	Eastern garter snake	Kruskal-Wallis X^2 (p)
Number	143	33	
Number of snakes in group	1.58 ± 0.09	1.39 ± 0.12	0.4 (NS)
Canopy cover (%)	49.64 ± 2.94	45.71 ± 2.97	7.50 (0.05)
Cloud cover (%)	28.85 ± 2.51	41.06 ± 5.42	4.46 (0.03)
Hit by sun (%)	38.47 ± 2.62	36.13 ± 5.60	0.16 (NS)
Visible (%)	58.29 ± 2.71	55.76 ± 5.74	0.02 (NS)
Distance to water (cm)	83.75 ± 5.64	147.97 ± 9.82	26.67 (0.0001)
Height above water (cm)	81.27 ± 8.53	100 ± 0	0.58 (NS)
Distance to path (cm)	157.49 ± 6.83	91.48 ± 8.44	23.98 (0.0001)
Air temperature (°C)	21.94 ± 0.42	19.70 ± 0.72	3.24 (0.07)
Water temperature (°C)	22.22 ± 0.31	18.45 ± 0.57	25.72 (0.0001)

snakes. However, compared to random points, water snakes preferred leaves, and branches and logs, compared to the random points ($X^2 = 43.4$, $P < 0.05$), supporting prediction 2. Of the 27 water snakes on branches, 22 were on branches suspended above the water (the other branches were on the ground). There were no significant differences between garter snake basking sites and random sites ($X^2 = 2.1$).

Water snakes seemed to bask under all canopy covers, and garter snakes primarily basked in places with 50–75% canopy cover (figure 3). Both species basked when the cloud cover varied from 0—nearly 100%, but water snakes usually basked when there was less cloud cover than did garter snakes (less than 25%, figure 4), re-entering the water or changing basking site, when they became shaded. Although there were no species differences in amount of the snake exposed to the sun when basking, both species generally had less than 59% of their body exposed much of the time (figure 5).

Both water and garter snakes showed a positive relationship between the air and water temperature when snakes were basking (figure 6, $r = 0.52$, $P < 0.0001$, $r - 0.70$, $P < 0.0001$, respectively). Both species were observed basking only when the air temperature ranged from 12–30°C, and when the water temperature was over 15°C, although garter snakes tended to bask at cooler temperatures than water snakes. However, both garter snakes and water snakes were observed basking when air temperatures were as low as 12°C and when water temperatures were as low as 15°C, rejecting prediction three.

Water snakes along the Raritan Canal bask on logs and overhanging branches more often than garter snakes, they bask nearer to the water and farther from the path, and they bask more when cloud cover is less. Water snakes bask when it is warmer than do garter snakes.

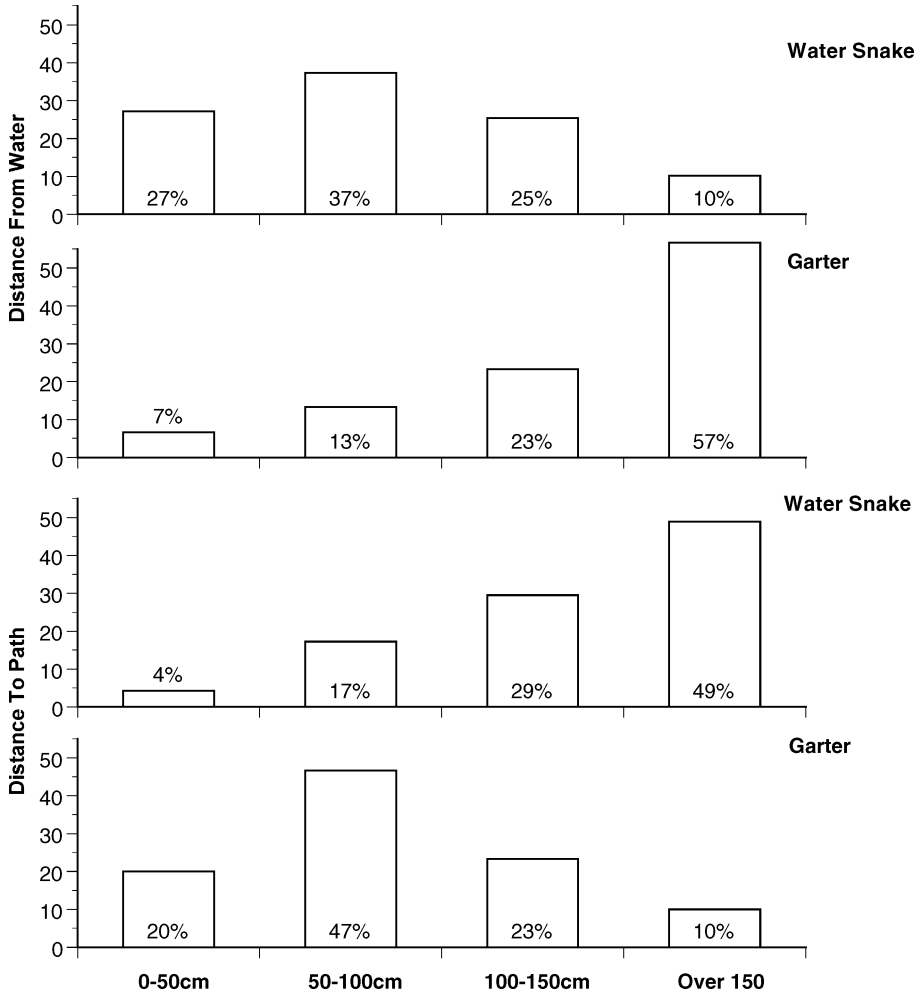

Figure 1. Distance garter and water snakes basked from the water's edge and the towpath.

Discussion

Habitat selection

Unlike many places where water snakes live (see Tiebout and Cary, 1987; Weatherhead and Robertson, 1992), the snakes we examined lived mainly in a narrow linear habitat corridor or band along the banks of the Raritan Canal, with less habitat complexity because of the urban environment. There were no marshy areas, open ponds or marshes, or shallow water embayments since the canal was built deep enough for boat travel. Further, the canal is maintained by the local water authority, and they remove all fallen logs or branches from

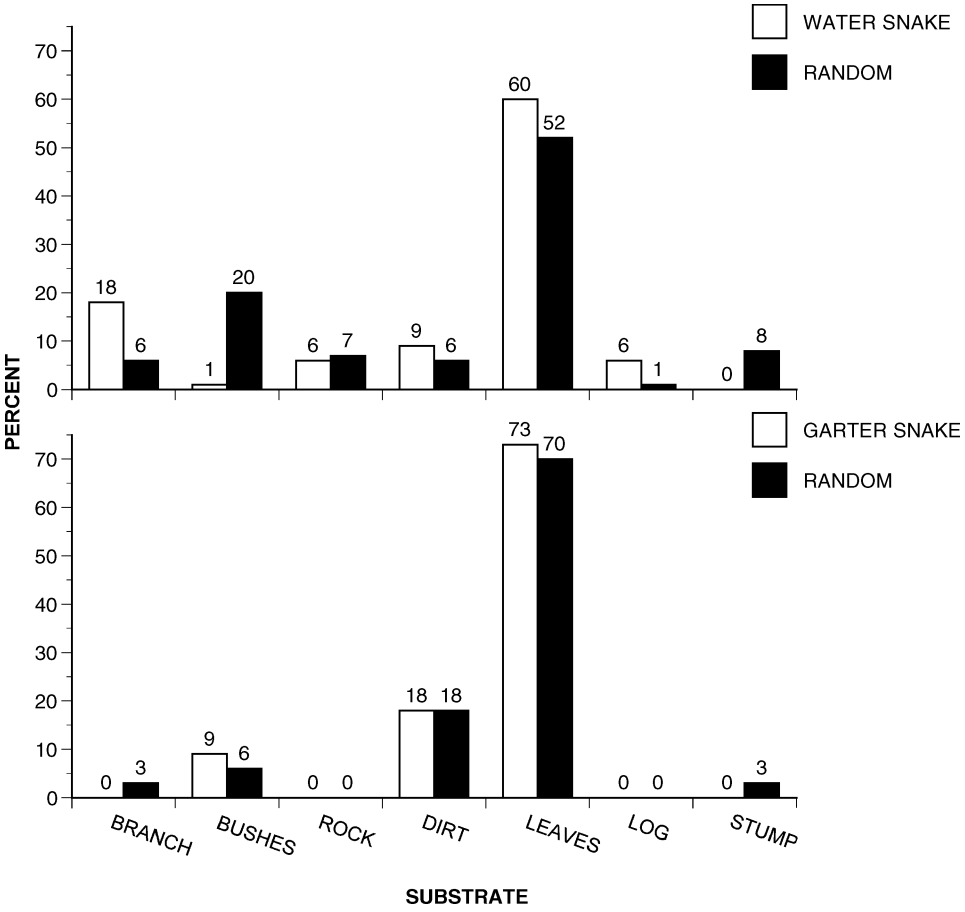

Figure 2. Substrate used for basking by garter and water snakes (open bars), compared to random locations along the Raritan Canal, New Jersey.

the water at the end of winter. The number of basking sites is limited, forcing the snakes to select sites on the bank. The linear nature of the habitat, and the frequency of people walking or jogging along the tow path further restricts the available basking sites. Further, since there are no basking sites out in the water, as occurs elsewhere (Tiebout and Cary, 1987; Weatherhead and Robertson, 1992), the water snakes are forced to bask along the banks, close to where people and other predators can move by.

The tow path, however, provides openings in the canopy, allowing sun penetration to the ground. Garter snakes responded by selecting basking sites on leaves and dirt at the side of the tow path where they are partly hidden in the vegetation, but are maximally exposed to the sunlight. Further, some of the garter snakes could have been gravid, and selected basking sites that were in full sun for much of the day (beside the trail). They usually were close to vegetation, however, where they had easy escape. Patrick *et al.* (1999) commented

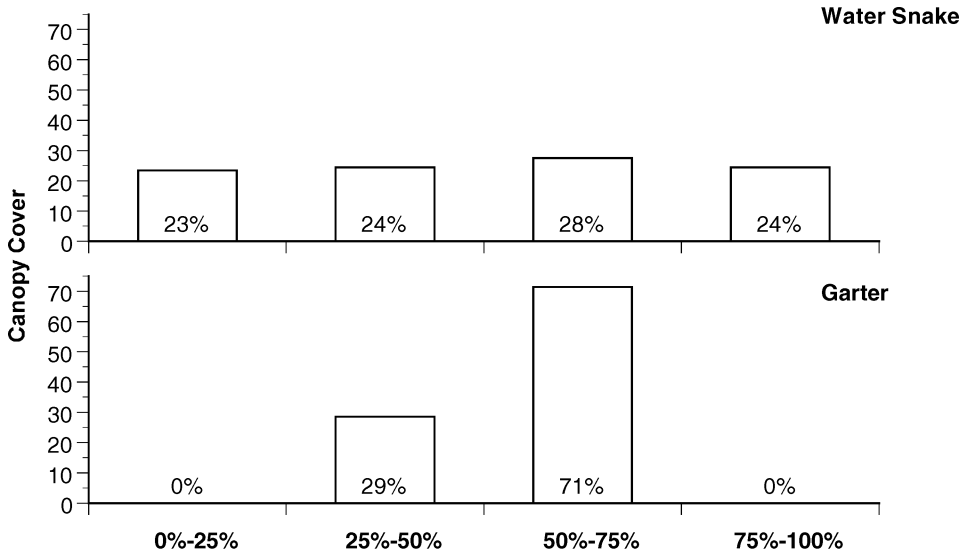

Figure 3. Canopy cover over garter and water snakes basking along the Raritan Canal, New Jersey.

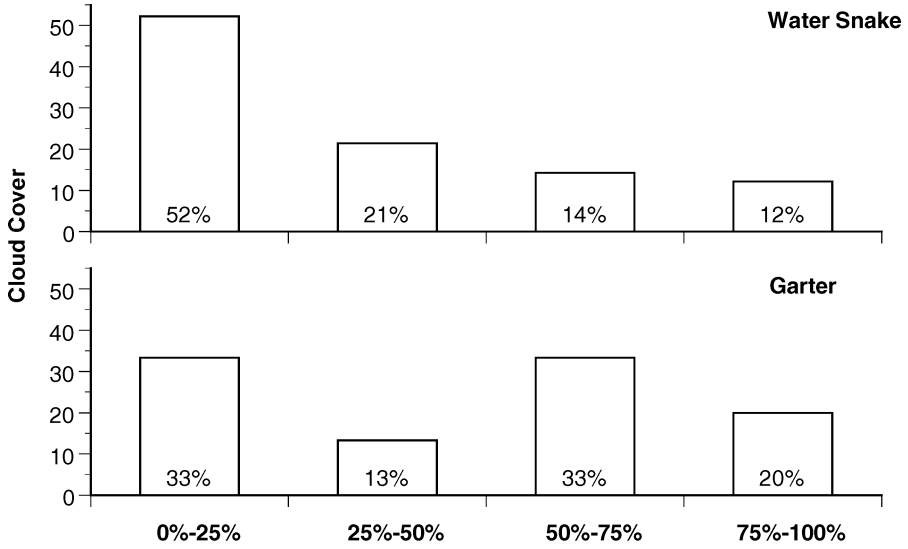

Figure 4. Cloud cover when garter and water snakes basked along the Raritan Canal, New Jersey.

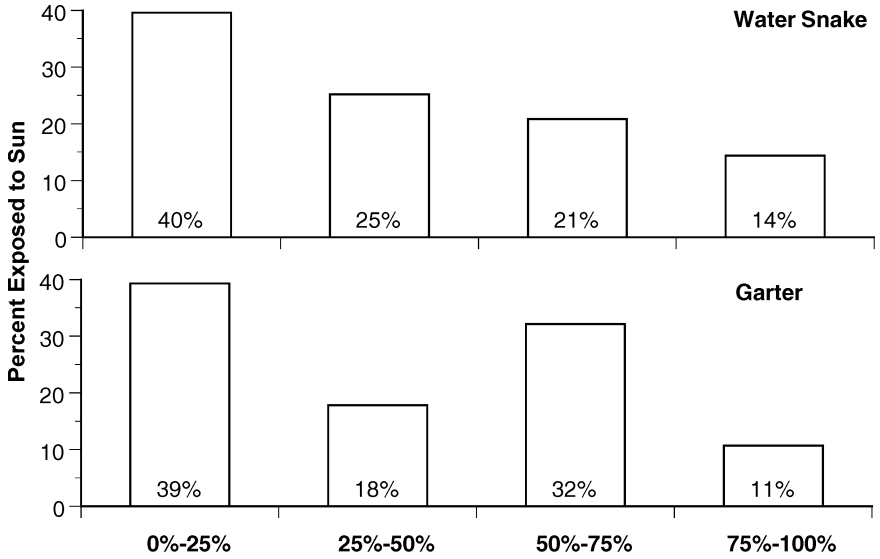

Figure 5. Amount of body of snake exposed to the sun when basking.

on the trade-offs between basking for gestation and foraging, but we suggest there is also a trade-off between selection of suitable sites for maximum basking and predator- (and human disturbance) free sites. This involved a trade-off between predation risk and resource acquisition (Downes, 2001).

Brown water snakes (*Nerodia taxispilota*) are not randomly distributed, and are associated with steep-banked outer bends of rivers and availability of perch sites (Mills *et al.*, 1995). Because the Raritan Canal was man-made, the banks are about the same steepness throughout, and there are no bends in the canal. The water snakes select sites closer to the water, allowing for rapid departure in the face of predators or human disturbance. Water snakes often basked while on branches that hung over the water, allowing them both access to sun and rapid departure into the water (they just dropped down). While garter snakes responded to predators (including people) by moving a short distance into the vegetation, water snakes invariably went immediately into the water and swam away close to the bank, usually hidden from view. Weatherhead and Robertson (1992) found that basking snakes reatreated to the water sooner when perched lower, indicating that they are more vulnerable to predators when lower. We did not find this difference. Diurnal basking is associated with wounds in water snakes, an indication of predation pressure (Mushinsky and Miller, 1993).

The preferences of water snakes for overhanging branches and logs, compared to the relative paucity of such sites (as determined from the random points) indicates that these habitats may be limiting. Indeed, in the previous year, before the water authority personnel removed large logs and branches from the water, 112 of 192 (58%) of the basking water snakes were on logs or branches of trees that had fallen into the canal (J. Burger, unpubl. data). The average number of snakes observed on a log was 4 ± 1, compared to the 2.2 ± 1.6

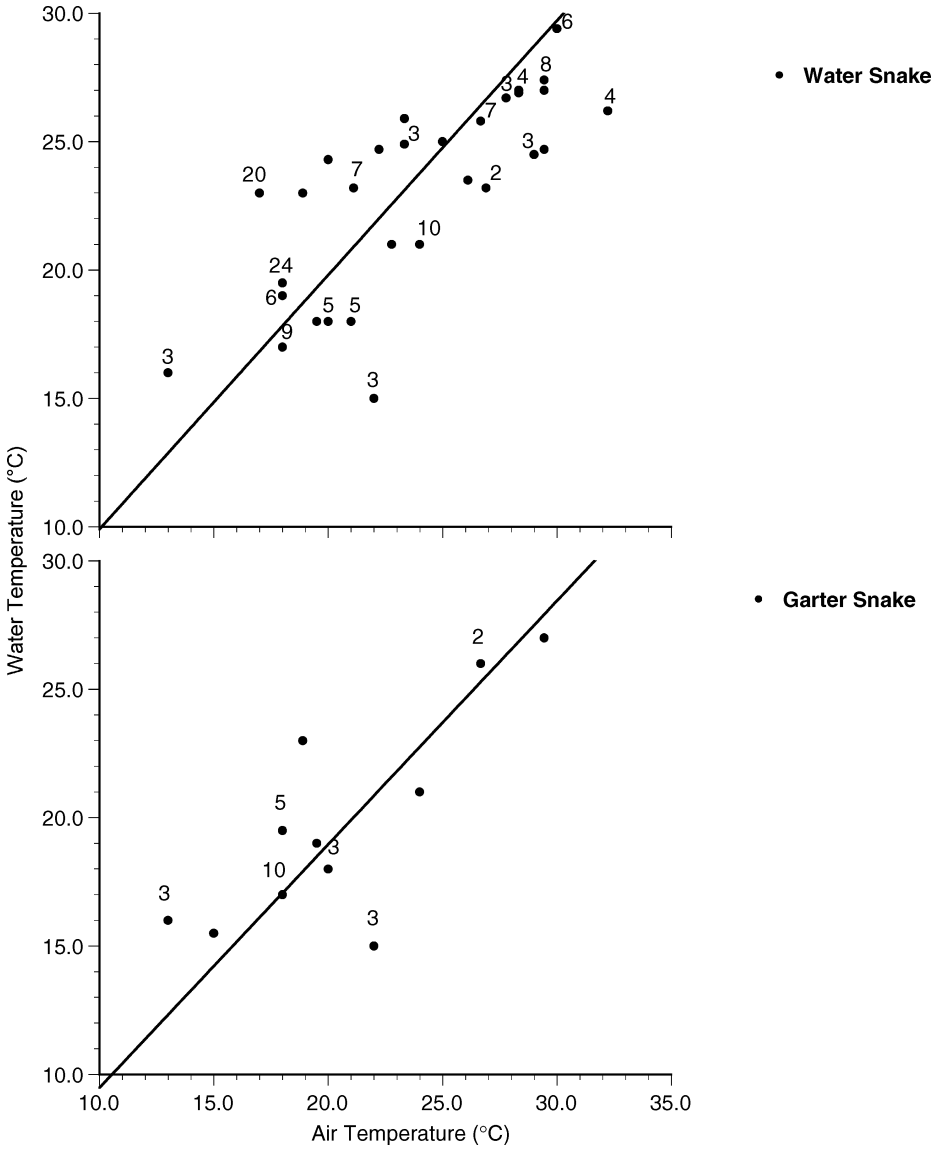

Figure 6. Water and air temperature when water and garter snakes were basking along the Raritan Canal, New Jersey. A dot can represent more than one snake.

in this study. Logs in the water provide ideal basking sites because they are exposed to the sun and are closer to the water and easy escape.

One aspect that should be examined in future studies is whether the heads of basking snakes are always visible; that is, whether the snake has visibility of approaching predators

and is thus vigilant. This decision, which way to face, clearly has tradeoffs with respect to thermoregulation and predation (see Lima and Dill, 1990 for behavioral decision-making).

Finally, it should be noted that the lack of basking places was problemmatic for water snakes. Resource managers could improve the habitat by leaving fallen logs in the water to provide more basking sites. Mowing could be restricted to only those places where it was necessary for operations, rather than to provide a mowed look.

Temperature relationships

We initiated the study in the spring before any snakes were basking, and thus the temperatures recorded in this study reflect when the snakes began to bask. In this study, more water snakes basked when the average water temperature was 19°C. Robertson and Weatherhead (1992) found that water snakes basked more frequently as the temperature of the air increased relative to the water, and our data confirm this observation. Basking ceased on hot days when the water temperature was above 30°C and the air temperature was above 32°C.

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