Reproductive output.—We collected one gravid female (field number NAT1223) at the Peixe locality. She had 1480 unyolked, black eggs in her abdomen. All eggs were 1 mm in diameter. She had a noticeably greater girth to her body relative to two non-gravid females collected at the Tocantopolis locality.

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Rain-Harvesting in a Wild Population of *Crotalus s. scutulatus* (Serpentes: Viperidae)

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Mohave Rattlesnakes (*Crotalus s. scutulatus*) inhabit many of the desert regions of the southwestern United States and northcentral Mexico. Throughout much of the range of *C. s. scutulatus*, the dominant plant is Creosote Bush (*Larrea tridentata*), which is widely spaced, and the terrain is mostly devoid of rock outcroppings and other significant topographic features. This habitat is also characterized by dry, porous soils that rapidly absorb rainfall, creating little opportunity for surface water to accumulate. Most precipitation in the Mohave Desert, where this study was conducted, occurs during the winter. Summer monsoon rains are less predictable and less significant than in the more southern Sonoran and Chihuahuan Deserts (Jaeger 1957), where *C. s. scutulatus* also occurs.

Several authors have described viperid snakes drinking water from the external surfaces of their own skin. Bogert (1927) describes a technique for captive husbandry of "rattlesnakes taken on the desert miles from water" as requiring water to be "sprayed upon them, as well as upon the rocks in their cage." He goes on to describe the snakes "sucking the water off the rocks and sometimes off their own backs." Also referring to captive animals, Hediger (1964) describes "some rattlesnakes" as preferring to "drink drops from the scales on their own bodies." Greene (1997) describes watching a wild Terciopelo (*Bothrops asper*) "drinking rain droplets off her own skin" in a Costa Rican rainforest. Andrade and Abe (2000) report captive juvenile Brazilian Lanceheads (*Bothrops moojeni*) coiling when sprayed with water, which was trapped between body loops and ingested. Captive Peringuey's Adders (*Bitis peringueyi*) from the Namib Desert have twice been reported to flatten their bodies when sprayed with water, which they then "drink" (Robinson and Hughes 1978) or "lick" (Louw 1972) from their own skin. Aird and Aird (1990) reported a captive adult female Great Basin Rattlesnake (*Crotalus oreganus lutosus*) in an outdoor enclosure flattening her body, forming concentric coils, and drinking rainwater trapped between the coils. A single observation of a wild xeric rattlesnake, *Crotalus oreganus concolor*, drinking rainwater from its skin was reported by Ashton and Johnson (1998).

Body posturing has been reported to enhance the collection of water from the skin by some desert lizards, including *Phrynocephalus helioscopus* (Schwenk and Greene 1987), *Phrynosoma cornutum* (Sherbrooke 1990), *P. platyrhinos* (Peterson 1998), *P. modestum* (Sherbrooke 2002), and *Trapelus pallidus, T. mutabilis,* and *T. flavimaculatus* (Vesely and Modry 2002). The term "rain-harvesting" was first used by Sherbrooke (1990) to describe the combination of integumental microstructure that enhances capillary movement of water and associated stereotypical posturing by *Phrynosoma cornutum* to collect and ingest rainwater.

I herein use "rain-harvesting" to describe the behavior of wild *C. s. scutulatus* by which they adopt a stereotypical posture to collect rainwater, which they then drink from the surface of their skin.

Methods.—Ten male and 10 female adult (> 180 g) Mohave Rattlesnakes were surgically implanted (Reinert and Cundall 1982) with temperature-sensing radio transmitters (model SI-2T, Holohil Ltd., Ontario, Canada) and radio-tracked for periods ranging from 18 days to 32 months (mean = 16 months).

Observations were made from August 2001 through April 2004, which involved > 2700 individual encounters with telemetered *C. s. scutulatus* and 84 chance encounters with 40 non-telemetered specimens. These observations were made in all seasons, at all times of day, and in a wide variety of weather conditions, including rainfall.

The study site is in the western Mohave Desert near Victorville, San Bernardino County, California, USA (ca. 34°36'N, 117°10'W) on a Creosote Bush-dominated bajada at a median elevation of about 975 m.

Current and historical precipitation data were obtained from the National Oceanic and Atmospheric Administration for its "Victorville Pump Plant" station (COOP ID 049325), located 14 km SW of the study area.

Results.—Individual *C. s. scutulatus* were visible on 1633 occasions. In 1097 of these observations (67%), they were found motionless in round "resting/ambush" coils, in which the anterior body was coiled on top of and covering the posterior body and tail. The head rested on top, oriented to face away from the center of the coil, with the axis of the head usually on a radius of the coils. The crown of the head was usually level or the nose was slightly elevated (Fig. 1).

In 12 of 16 observations during rainfall, the snakes were observed to be coiled with the body spiraling out from the tail in the center; the coils of the anterior body were adjacent to, rather than on top of, the coils of the posterior body. The abdominal area was extraordinarily flattened dorso-ventrally, maximizing the surface area exposed to the rain. Adjacent posterior abdominal coils were in contact, forming a shallow trough between them where rainwater collected. The position of the head was adjusted to a nose-down attitude, placing the rostral area in the trough formed by the adjacent abdominal coils (Fig. 2). This posture and behavior was also observed on six additional occasions shortly after rainfall had stopped but while the snakes were still wet. These 18 observations involved 12 different animals during 9 storms in 3 calendar years.

In each case where rain-harvesting behavior was observed, the snake positioned its head so that the rostral area was within about 2 mm of, or actually in contact with, the animal's skin. Slight rhythmic movement could be observed in the temporal-mandibular musculature and the rostral area was moved every few seconds to different areas of the trough between adjacent coils. Although actual jaw movement could not always be seen, water could be observed to disappear as it came into contact with the snake's rostral area.

On 10 July 2002, an 828 mm SVL (snout–vent length) male *C. s. scutulatus* (Css25) was observed just as a summer evening thunderstorm struck. The snake was in a resting/ambush coil, under the edge of overhanging Mormon Tea (*Ephedra nevadensis*) foliage, when a few large scattered raindrops began to fall. In < 10 seconds, he moved about 20 cm to a position that was not overhung by the shrub, assumed the rain-harvesting posture and began to search for water on his own skin in a very animated manner. This occurred even before he or the surrounding substrate was visibly wet. Immediately after this observation, I returned to a 770 mm SVL female (Css20) that had been visited 22 minutes before and found her in rain-harvesting posture, having also moved from under foliage (*Larrea*), where she had earlier been in a resting/ambush coil.

On three other occasions, Mohave Rattlesnakes were observed to move away from their rain-harvesting positions (usually to retreat from the observer) and the substrate under each snake was noted to be dry, contrasting with the adjacent soil that had been darkened by moisture.

Study animals ignored large granite rock outcrops in parts of the study site where temporary puddles of rainwater can be expected to occur. In some areas frequented by the study animals,

Fig. 1. *Crotalus s. scutulatus* (Css42, 1 May 2004) in stereotypical resting/ambush posture.

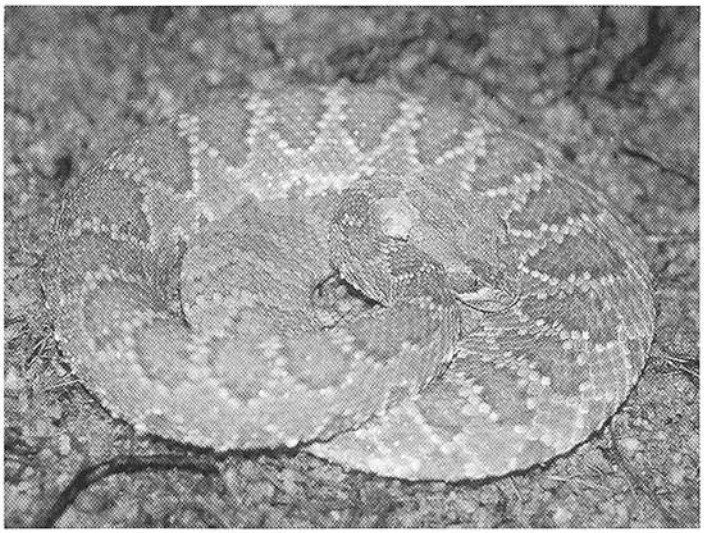

Fig. 2. *Crotalus s. scutulatus* (Css03, 30 October 2001) in stereotypical rain-harvesting posture.

the ground is littered with cobble (stones 65–256 mm) that accumulated rainwater on their surfaces in quantities that appeared at least comparable to the water that collected on the snakes' bodies. While other small creatures (e.g., *Hadrurus* scorpions) drank from these small rocks and from dripping vegetation, *C. s. scutulatus* were never observed to use water from these or any surfaces except their own bodies.

Crotalus s. scutulatus were observed harvesting rainwater in March, April, July, August, September, October, and November. Mean body and air temperatures during observed rain-harvesting were 18.2°C (range 12 – 32; N = 13) and 17.6°C (range 11 – 30; N = 16), respectively. Fewer body temperatures were recorded than air temperatures because of transmitter failure (N = 1) and chance observations of non-telemetered snakes (N = 2).

Study animals were visited on 22 occasions during rainfall events in November, January and March. With the exception of one mid-March observation, there was no indication that the animals emerged from their winter shelters (mammal burrows) to drink.

Discussion.—*C. s. scutulatus* are ambush predators and, in this study, 67% of their time above ground was spent in resting/ambush coils. By minimizing exposed skin, this position minimizes transdermal moisture loss in conditions of very low humidity (Cohen 1975). Compared to the resting/ambush coil, the rain-harvesting posture increases exposed skin surface (thereby intercepting more rain), decreases the slope of the lateral skin surface (thereby slowing water runoff), and creates troughs between adjacent coils where water accumulates. Although water is also available on the surface of small stones and foliage during and immediately after rain, the rain-harvesting posture is more efficient in that it does not require time to be spent during typically brief storms searching for a suitable surface from which to drink.

Drinking snakes' core body temperatures were very close to the surrounding air temperatures (mean difference < 1°C) and revealed that they were willing to endure body temperatures as low as 12°C to harvest rainwater. Sherbrooke (1990) observed nocturnal emergence, presumable at lower temperatures, of Texas horned lizards (*Phrynosoma cornutum*) to harvest rain during nighttime storms.

Desert rattlesnakes, like other desert animals, depend on metabolic water obtained from the food they consume. Nonetheless, it has been shown that reptiles cannot produce enough metabolic water to entirely compensate for water loss (Nagy 1987). *Crotalus s. scutulatus* appears to be adapted to efficiently exploit one of the rarest yet most important resources in xeric environments, especially considering that nearly 70% of annual precipitation in this study area occurs from December through March (National Climatic Data Center 2002), when cold temperatures apparently prevent *C. s. scutulatus* from taking advantage of it.

Two observations of *C. s. scutulatus* moving out from under foliage at the first hint of rain suggest that these snakes take up rainfall-harvesting positions very early in a rainfall event. It should be noted, however, that these two observations were made during a storm season (October 2001–September 2002) that yielded 71% less precipitation than the 30-year mean for the area (National Climatic Data Center 2001–2002 and 2002). Observations of dry ground under other rain-harvesting specimens is consistent with such early movements but is equally consistent with those snakes being in suitable rain-harvesting locations before rainfall began.

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