ACTIVITIES OF FOUR SPECIES OF LAND SNAILS AT LOW TEMPERATURES

During their daily survival, terrestrial gastropods have two primary requirements they need to fulfill: the intake of adequate food and the maintenance of proper hydration. Food intake requires that the animals be active, but activity results in water loss as evaporation from the body surfaces and as slime left behind (Riddle, 1983; Cook, 2001). The surface a gastropod is on must be sufficiently wet, the air humidity adequately high, and its food of a high enough water content so that daily activity doesn't result in a negative water balance.

When rains are infrequent, fog interception and dew formation may become the only sources of water. Some desert snails indeed rely on dew (Yom-Tov, 1971). But the survival significance of dew and fog for non-desert species has not been demonstrated. When the daytime temperatures are 14 to 20°C and the humidity is around 50%, dew will form if the night-time temperatures fall below 10 °C (Lawrence, 2005; Wallace & Hobbs, 2006). Therefore, if the terrestrial gastropods of relatively cool and dry climates rely on dew and fog to maintain their hydration levels, they need to be active at low night-time temperatures, arbitrarily defined as above freezing but below 10°C. To support this hypothesis, I present data from field observations and experiments with captive snails.

For three consecutive mornings around sunrise between 17 and 19 October 2008, I observed snails on a hillside on the outskirts of the city of Kastamonu, Turkey (41.36°N, 33.76°E). The ground was covered with grasses and small herbaceous plants, but there were no trees, substantial plant debris or outcrops for shelter. Nevertheless, there were large numbers of four snail species: three in the Enidae, *Chondrus tournefortianus* (Férussac 1821), *C. zebra* (Olivier 1801), *Zebrina detrita* (O.F. Müller 1774), that were identified by their shell characteristics, and one in the Hygromiidae, *Monacha* (*Metatheba*) *samsunensis* (L. Pfeiffer 1868) that was identified by the dissection of a specimen (Hausdorf, 2000).

At 7:30 a.m. on 17 October, the air temperature a few centimeters above the ground was 4.5 °C (temperatures were accurate within about 1 °C). A heavy fog was lifting; the soil was wet and the surfaces of plants were covered with water droplets. Individuals of all four species were active on the soil and on the plants.

The next morning at 7:30 a.m., the temperature near the ground was 5.5°C. There was no fog, but the soil and the plants were wet with dew. All four species were active, including both adults and juveniles of *C. tournefortianus*. By 9:50 a.m., the air temperature had risen to 16 °C and numerous *C. zebra* had become dormant on a nearby concrete sidewalk. On both 17 and 18 October the daylight hours were sunny without any precipitation.

At 7:30 a.m. on 19 October, the air temperature was 11 °C. There was much less dew on the plants compared to the previous mornings. Nevertheless, the snails were active. I observed a pair of *C. tournefortianus* mating on the ground (Örstan, 2009).

In the morning of 17 October, I took approximately 90 live *C. tournefortianus* and 44 live *C. zebra*. I kept the snails in two separate containers with water, but without food for several hours and collected faeces from both containers. This demonstrated that both species had been feeding during the preceding night. The faeces of both species consisted mainly of brownish plant fragments and some microscopic fungal hyphae; there were no green plant parts.

To test the reactions of these snails to artificially induced low temperatures, I placed a container with two live *C. zebra*, one *Z. detrita* and one *M. samsunensis* outdoors on several occasions at temperatures from 0 to 9°C for up to 10 hours. I did not notice reproducible patterns in their behaviour, but all three species displayed intermittent or continuous activity for varying periods. I also placed the container inside a refrigerator (about 3°C) on four occasions for up to seven hours. During one test, I observed *Z. detrita* and both specimens of *C. zebra* crawling after five hours in the refrigerator.

The suitability of a surface for dew formation depends on its wetting properties (Agam & Berliner, 2006). The examinations of pictures of *Z. detrita*, *M. samsunensis* and *C. tournefortianus* taken in the field revealed that their shells were covered with water droplets, suggesting that water had condensed on their shells. To confirm this, I sealed *Z. detrita*, *M. samsunensis* and *C. zebra* with water containers in a box at about 19.5°C for one hour to saturate the air with water vapor, followed by 90 minutes inside a refrigerator. In the refrigerator the shells of all three species became covered with water droplets, indicating that the outer surfaces of their shells are conducive to the formation of dew. Dew formation directly on their shells may help snails conserve water by retarding the rate of evaporation of body water through their shells.

My observations suggest that in temperate climatic zones considerable terrestrial gastropod activity may take place at temperatures between 0 and 10°C. In fact, Cameron (1970) showed that the daily activity at 100% humidity of captive *Arianta arbustorum* peaked at 8 °C, while the activity levels of *Cepaea nemoralis* and *C. hortensis* were about the same between 8 and 26°C.

The Kastamonu province of Turkey, near the border of the relatively dry central Anatolian zone, has an average annual precipitation (Koçman, 1993) of approximately 500 mm. The snails from the study area were acclimatized to be active between 0 and 10°C. Their utilization of water from dew and fog at low temperatures may be crucial for their long-term survival by allowing for opportunistic feeding and mating forays during rainless periods when they would otherwise be forced to be dormant.

AGAM N & BERLINER PR 2006 Dew formation and water vapor adsorption in semi-arid environments—A review. *Journal of Arid Environments* **65**: 572–590.

CAMERON RAD 1970 The effect of temperature on the activity of three species of helicid snail (Mollusca: Gastropoda). *Journal of Zoology* **162**: 303–315.

COOK A 2001 Behavioural ecology: on doing the right thing, in the right place at the right time. *In:* BARKER GM (ed.) *The Biology of Terrestrial Molluscs*, pp. 447–487. CABI Publishing, New York.

HAUSDORF B 2000 The genus *Monacha* in Turkey (Gastropoda: Pulmonata: Hygromiidae). *Archiv für Molluskenkunde* **128**: 61–151.

KOÇMAN A 1993 *Türkiye Iklimi* [Climate of Turkey]. Ege University, Geography Department, Izmir. 83 pp.

LAWRENCE MG 2005 The relationship between relative humidity and the dewpoint temperature in moist air. *Bulletin of the American Meteorological Society* **86**: 225–233.

ÖRSTAN A 2009 An observation of the mating of *Chondrus tournefortianus* (Pulmonata: Enidae). *Zoology in the Middle East* **48**: 117–118.

RIDDLE WA 1983 Physiological ecology of land snails and slugs. *In:* RUSSELL-HUNTER WD (ed.) *The Mollusca* 6: Ecology, pp. 431–461. Academic Press, London.

WALLACE JM & HOBBS PV 2006 *Atmospheric Science: An Introductory Survey.* Academic Press, London. 483 pp.

YOM-TOV Y 1971 The biology of two desert snails *Trochoidea* (*Xerocrassa*) *seetzeni* and *Sphincterochila boissieri Israel. Journal of Zoology* **20**: 231–248.

Aydin Örstan
Section of Mollusks
Carnegie Museum of Natural History
Pittsburgh, Pennsylvania 15213–4080, USA

Contact author : pulmonate@earthlink.net