

Diurnal Seasonal Activity of *Cryptobranchus alleganiensis* (Hellbender) in North Carolina

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Abstract - *Cryptobranchus alleganiensis* (Hellbenders) are primarily nocturnal salamanders, emerging at night from their daytime rock retreats. Most populations exhibit infrequent diurnal activity, mainly during the breeding season or during overcast or rainy days. This paper reports on a population of Hellbenders from Transylvania County, NC, where 148 observations of diurnal activity were made during 51 person hours over a 3-yr period. Hellbenders were most diurnally active during the September breeding season (mean = 16.3 individuals/person hr), but also exhibited high levels of diurnal activity during summer months, especially in May (mean = 11.4 individuals/person hr). Diurnal activity was not correlated with cloud cover, water depth, or time of day when searches were conducted, but was positively correlated with water temperature. Previous literature and numerous surveys conducted by the author in other parts of the Hellbender's range suggest that this North Carolina population is unique in its diurnal activity, which is possibly related to factors such as prey availability, intraspecific competition, or predator threats.

Introduction

Daily activity cycles of animals are usually predictable (i.e., diurnal, nocturnal, crepuscular), dependent to a large part on interactions between a species and its prey or predators, as well as factors such as temperature and moisture tolerance. However, populations or individuals of a species may shift their activity patterns because of a variety of factors including prey availability (Hansen and Closs 2005), intraspecific competition for resources (Alanara et al. 2001), and predator threats (Fraser et al. 2004). Therefore, observations of daily activity patterns that differ markedly from well-established patterns for a species may offer some insight into the community ecology of an ecosystem. Knowledge of daily and seasonal activity patterns is also useful for developing methods to monitor populations (Humphries and Pauley 2000). In this study, I focus on diurnal activity patterns of *Cryptobranchus alleganiensis* Daudin (Hellbenders) in North Carolina.

Hellbenders are large, aquatic salamanders that inhabit streams of the eastern United States (Petranka 1998) and feed primarily on crayfish (Green 1934, Nickerson and Mays 1973, Swanson 1948). It is well documented that Hellbenders are primarily nocturnal (Coatney 1982, Humphries and Pauley 2000, Humphries and Pauley 2005; Noeske and Nickerson 1979, Nickerson 1977-78, Smith 1961; Townsend 1882). The Hellbender's body, especially the tail, is sensitive to white light; a trait that apparently aids in concealment during

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daylight hours (Reese 1906). Diurnal activity, to any great extent, has only been documented during the breeding season (late August–early October) when numerous individuals may be seen walking around areas presumably containing nesting sites (Bishop 1941, Green 1934, Nickerson and Mays 1973, Nickerson and Tohulka 1986, Smith 1907). Nickerson and Mays (1973) noticed some individuals in the open during the day in June, July, and August; however, greater numbers were active near the breeding season in September and October. They reported on a diurnal emergence of 12 Hellbenders just after a moderate rain began to fall during midday in September, suggesting that rain coupled with overcast skies may have stimulated activity. Humphries and Pauley (2000) documented a seasonal shift in nocturnal activity of Hellbenders in West Virginia with high levels of activity during May and June followed by a decrease in activity later in the summer and fall. During diurnal rock-turning surveys of a study site in North Carolina in 2002, I began to notice numerous Hellbenders actively walking the stream bottom (see Fig. 1). Here, I report on seasonal activity patterns of the only known population of Hellbenders exhibiting considerable diurnal activity.

Methods

Field site description

The study site consisted of a 400-m stretch of one stream and a 500-m stretch of a connecting stream in Transylvania County, NC, within Pisgah National Forest; both streams are tributaries of the French Broad River. The stream names are not given because of a history of collection of Hellbenders



Figure 1. Diurnally-active adult Hellbender in a typical section of the North Carolina study site.

following publication of study sites. The study site's elevation is 716 m. Stream width averaged 10–15 m, and water depth at average flow ranged from 15 cm in riffles to 1.5 m in pools, but the streams mainly consisted of runs and riffles averaging 30–45 cm deep. The substrate consisted of medium-sized cobble with numerous large, flat rocks and boulders scattered along the bottom. The water was extremely clear unless heavy rains had fallen within a day of surveys.

Survey techniques

The site was surveyed during the day from 17 April 2003–13 September 2005 by slowly walking the stream and searching for active Hellbenders with the aid of polarized sunglasses. The site was not surveyed from December–March during any of the years. I usually surveyed the site alone, but some surveys included as many as 5 people searching. To standardize effort, the number of Hellbenders captured was divided by the actual cumulative time researchers spent searching for Hellbenders. Each Hellbender was captured, weighed, measured, sexed, individually marked with a PIT tag injected into the dorsum at the base of the tail, and released where it was captured. Measurements and individual identification were performed for a concurrent mark-recapture study, and those results are not presented in this paper. During each survey, I also measured water temperature and sky conditions (e.g., sunny, partly cloudy, cloudy), and relative water-depth measurements were gathered from a USGS gauging station along the stream. I classified sunny conditions as a sky with few, if any, clouds; partly cloudy conditions represented skies with approximately 50% cloud cover; cloudy conditions represented completely overcast skies. The site was not searched during rainy conditions, as rain caused disturbance on the water surface, making visual surveys difficult and inaccurate.

Results

During 34 surveys (51 person hrs) from Apr 2003–Sep 2005, I made 148 observations of diurnally active Hellbenders (144 adults, 4 juveniles). Diurnal capture rates ranged from 0–30 Hellbenders/hr (mean = 7.4). Hellbenders were most diurnally active during September, with a mean of 16.3 individuals observed per hour, but were also highly diurnally active during May, with a mean of 11.4 individuals observed per hour (Fig. 2). The lowest levels of diurnal activity were observed in April and November, just before and after the winter months.

Fifty-two percent of surveys were conducted on sunny days, 16% on partly cloudy days, and 32% on cloudy days. Water temperature during surveys ranged from 8–18 °C (mean = 13 °C). Water depth (analogous to stream flow) during surveys ranged from 25–61 cm (mean = 38 cm) at the gauging station. Mean time of day when surveys were conducted was 1450 hrs (range = 945–1645 hrs). Diurnal activity was significantly correlated with water temperature ($r = 0.58$, $P = 0.02$), but not significantly correlated with cloud cover ($r = 0.01$, $P = 0.98$), water depth ($r = 0.23$,

$P = 0.19$), or time of day ($r = 0.28$, $P = 0.11$) (Spearman's correlation; SAS vers. 9.00, SAS Institute, Inc., Cary, NC).

Discussion

This is the first contemporary study to report on high levels of diurnal activity by Hellbenders outside of the breeding season. Diurnal activity of Hellbenders has rarely been reported in the literature, and I have only observed 2 diurnally-active Hellbenders in over 300 person hrs in 23 streams surveyed in Georgia and West Virginia between 1998 and 2005. In addition, a radiotelemetric study of Hellbender movements in the New River drainage of North Carolina did not reveal any diurnal activity (Ball 2001). Diurnal activity (and lack of nocturnal activity) of Hellbenders has been detected in a stream near my study sites (W.J. Humphries, unpubl. data). Future study of streams in other parts of the Hellbender's range may reveal other diurnal populations; however, at this point, high levels of diurnal activity appear to be unique to tributaries of the upper French Broad River in North Carolina. Whether or not diurnal activity replaces nocturnal activity in these populations is unknown. Five nocturnal surveys of my study site, totaling approximately 15 person hrs, did not reveal active Hellbenders, although one attempt at night to bait Hellbenders with tuna wrapped in cheesecloth resulted in 3 individuals quickly appearing to investigate the bait.

Hellbenders were most diurnally active during the September breeding season and into early October, but there was also a peak in diurnal activity

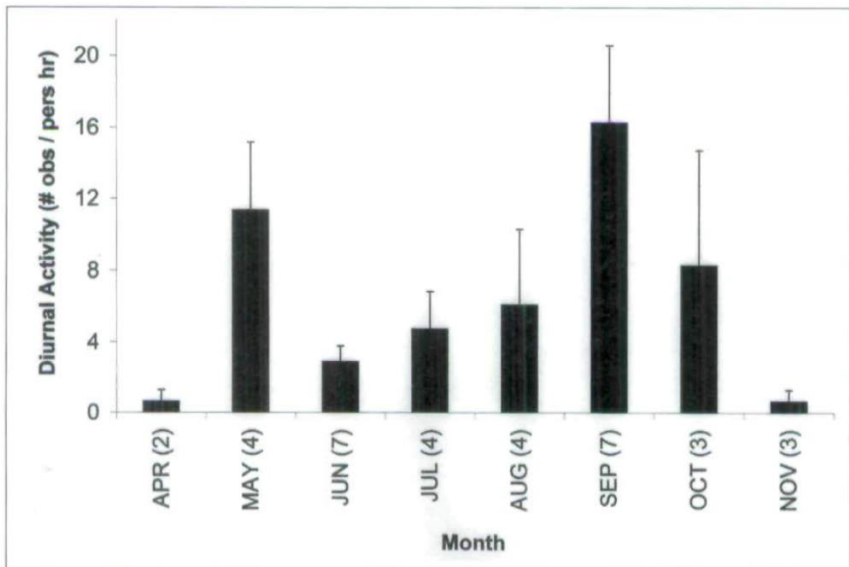


Figure 2. Diurnal activity of *Cryptobranchus alleganiensis* (Hellbenders) in Transylvania County, NC. Activity represents the mean of pooled data from April 2003–October 2005 with standard error bars shown. Number of surveys conducted per month is shown in parentheses.

during May. Though activity levels were lower from June–August, numerous individuals could easily be found either sitting or actively prowling the stream bottom during every survey conducted in those months. For example, in less than two hours of searching on a sunny day during June 2005, three research assistants and I observed 17 Hellbenders diurnally-active within a 300-m stream reach at this study site. Townsend (1882) reported on considerable numbers of diurnally-active Hellbenders in early summer in Pennsylvania, and Nickerson and Mays (1973) reported 12 diurnally-active Hellbenders after a light rain began to fall at their study site. Consistently high levels of diurnal activity, however, have not been reported. Elevated diurnal activity during May in this study was similar to the peak of nocturnal activity observed in West Virginia populations (Humphries and Pauley 2000), and this peak may be related to active foraging to maximize food intake associated with increased temperatures and an associated increase in physiological functions. In this North Carolina population, diurnal activity during the fall was most prevalent near nest rocks. One confirmed and two potential nest rocks were discovered during the study, and between 5 and 13 Hellbenders were observed around each rock within an area approximately 5 m in diameter. In addition to spatial differences (e.g., activity higher near nest rocks) during the breeding season, diurnal activity often varied in intensity from one day to another during the spring and summer. Reasons for these day-to-day variations in activity remain unknown.

The only environmental variable correlated with diurnal activity was water temperature, with Hellbenders becoming more active with increased temperature. However, this probably reflects the general inactivity of Hellbenders during late fall, winter, and early spring months and not necessarily a causal relationship between water temperature and warm-season activity patterns. Water depth and cloud cover were not correlated with diurnal activity. Hellbenders were diurnally active from spring through fall, even on sunny days and individuals were often found in the open in full sun. Thus, other factors not tested for in this study appeared to influence diurnal activity, possibly including fluctuations in hormone levels (Nickerson and Mays 1973), prey availability (Hansen and Closs 2005), intraspecific competition for resources (Alanara et al. 2001), and predator threats (Fraser et al. 2004).

Observations of Hellbender diurnal activity reported here provide a basis for future studies aimed at determining possible physiological, environmental, geographical, or community (e.g., predator, prey, or competition) relationships that influence daily activity patterns. Despite a wealth of literature pertaining to Hellbender life history, aspects of this rare species' ecology that deviate from normal patterns continue to be discovered. These deviations in life history offer insights into geographic variation, community ecology, and behavioral plasticity within animal populations.

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