Unique Herpetofauna of Murphy Lake State Game Area, Tuscola County, Michigan: Northern Dusky Salamander (*Desmognathus fuscus*) and Six-lined Racerunner (*Aspidoscelis sexlineata*)

by

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Thesis submitted to the Faculty of the

University of Michigan-Flint

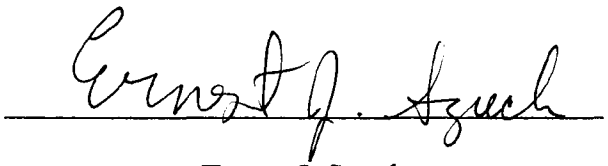
in partial fulfillment of the requirements for the degree of

Master of Science

in

Biology

APPROVED:



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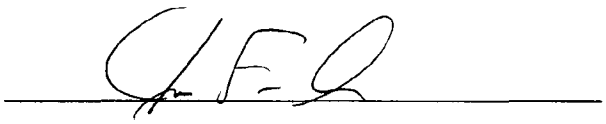

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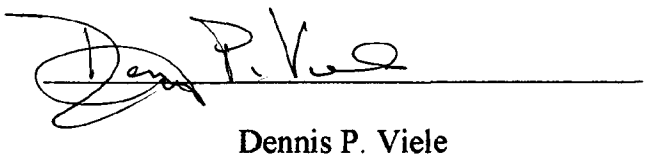

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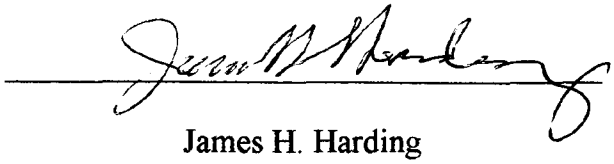

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December 2007
Flint, Michigan

Acknowledgements

Thank you to my family, friends and colleagues who have provided assistance in the field. Specifically, I would like to thank Melissa Borowiak, Laura Cochran, Zach Garman, Tiffany and Kyle Fender, Therese Long, Courtney Ostipow, Marvin Roberson, Joshua Springer, Ericca Stamper, Acacia White and the students from the 2006 Field Biology and Topics in Ecology Courses at the University of Michigan-Flint.

Additionally, I would like to thank Larry Atherton, Biology Department, University of Michigan-Flint, for helping acquire supplies; Fred Case, Retired Teacher and Orchid Expert for the Great Lakes Region, Saginaw, Michigan, for valuable discussions and knowledge of the game area; Paula Hildebrandt, Michigan State University Museum, for preservation of the *Desmognathus fuscus* voucher specimen; Ben Czinski, Director of Kresge Environmental Education Center (KEEC), and Eastern Michigan University for permission to perform research at KEEC in Lapeer County; Arnold Karr, Richard Robertson and Donald Bonnette, Cass City Field Office, Michigan Department of Natural Resources for permission to perform research at Murphy Lake State Game Area and for providing valuable information about the game area and Greg Schneider, Collection Manager, University of Michigan-Ann Arbor Museum of Zoology, for valuable discussions and knowledge of both species, in addition to providing specimens for use.

I would like to thank Dennis Viele, University of Michigan-Flint, for statistical support, encouragement, moral support and ecological monitoring supplies. Thanks to James Harding, Michigan State University Museum for encouraging me to pursue my passion for amphibians and reptiles. I had many insightful discussions with Jim that I will not forget, from where to go to

graduate school and what to study to local and global herpetological issues. Jim, we will get out to the research site next field season; I promise to make the time!

I would like to thank Ernie and Annie Szuch, University of Michigan-Flint. Ernie and Annie have helped in so many ways. They provided endless moral support and encouragement. Annie was often our photographer and could help me find any reference I needed. She also provided wonderful baked goods after a long day in the field. Thank you! Ernie taught me so much about ecology, nature and life through the many conversations, either in the field or after a long day in the field; they have been invaluable to me and will not be forgotten. I would have to say the most important lesson he taught me was to follow my heart! Thank you, Ernie. You are one of the reasons I am here studying amphibians and reptiles.

Thanks to John C. Carlson, my ex-husband, for the financial and moral support he provided. I would have not made it to where I am without your support early on in my graduate career!

Lastly, I would like to thank my family for all the support and encouragement (harassment) to finish school. To my brothers and sisters, yes, I finally graduated! Your little sister is finally growing up. To my mother, Mildred Yoder, thank you for all the support! I truly could not have done it without you. You have financially supported me and morally supported me through my path to graduation. Thanks for always being there!

Financial support for this project was provided from the Murchie Memorial Research Fund through the Biology Department, the Nick S. and Sharon G. George Research Fund, a Student Research Stipend through the Office of the Dean of the College of Arts and Sciences and a Graduate Student Research Assistantship through the Office of Research and the Office of Graduate Programs at the University of Michigan-Flint.

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THESIS ORGANIZATION

Four chapters are included in this thesis. The first chapter is an introduction that provides background information about *Desmognathus fuscus* and *Aspidoscelis sexlineata*. The second chapter includes two publications and a presentation abstract. The first publication, "Geographic Distribution for *Desmognathus fuscus*," was published in Herpetological Review in December 2005. This was the first documented record of *D. fuscus* in Michigan. The second publication is titled "Un-weathered (new) artificial cover objects effectively sample Plethodontid Salamanders in Michigan" which will be published in the December 2007 issue of Herpetological Review. The presentation abstract is titled "Northern Dusky Salamander: (*Desmognathus fuscus*): First State Record, Tuscola County, Michigan" which was presented at the Midwest Fish and Wildlife Conference in Grand Rapids, Michigan, in December 2005. The third chapter is a manuscript written for publication titled "Aspects of the natural history of a disjointed population of Six-lined Racerunners, *Aspidoscelis sexlineata*, located in Murphy Lake State Game Area, Tuscola County, Michigan" that will be submitted for publication after completion of this thesis. The final chapter is a discussion of how and whether to monitor and manage these disjointed populations. The literature cited for the introduction and discussion are presented together at the end of the discussion. The literature cited for the middle chapters are presented after each chapter.

INTRODUCTION

Goals

The overall goals of this study are to provide some basic biological information on the only populations of Northern Dusky Salamanders, *Desmognathus fuscus*, and Six-lined Racerunners, *Aspidoscelis sexlineata*, in Michigan. In addition to documenting *D. fuscus* in Michigan, the range of the population, artificial cover board use patterns and sympatric species were also examined. Subspecies status, morphological characteristics, population characteristics, habitat use and seasonal activity patterns for *A. sexlineata* were determined. Management suggestions are presented for both species. Additionally, artificial cover object studies of terrestrial salamanders are presented.

Background Information

Murphy Lake State Game Area (MLSGA) is located about three miles east of the Village of Millington in southern Tuscola County, Michigan. The game area contains 2,645 acres and is a forested oasis in the middle of a primarily agricultural landscape. Steep end-moraine ridges and pitted outwash deposits make up the game area (Murphy Lake State Game Area Strategic Plan 2004). Several habitats are found within the game area including: northern mesic forest, dry-mesic southern forest, emergent marshes, aspen stands, lowland hardwood stands, upland brush and planted shrubs, grasslands, lowland shrub and conifer stands (Murphy Lake State Game Area Strategic Plan 2004). Murphy Lake is located in the northern part of the game area and has several streams/tributaries flowing in and out of the lake. Murphy Lake State Game Area has unique fauna compared with other game areas in the region. It is home to the only populations of *Desmognathus fuscus* and *Aspidoscelis sexlineata* in the state of Michigan.

Desmognathus fuscus, the Northern Dusky Salamander, is a stream-dwelling member of the Plethodontid family of salamanders. *Desmognathus fuscus* can be identified by a light stripe running from the back of the eye to the jaw, hind legs significantly larger than the front legs and a keeled tail. *Desmognathus fuscus* was first documented in the state of Michigan in the fall of 2004 (Carlson and Szuch 2005). This sighting took place along a stream at MLSGA. Further searching lead to the discovery that *D. fuscus* was found along all streams in the game area that were between Murphy Lake Road and Millington Road. These stream-side habitats were often characterized by rolling hills and an Eastern Hemlock dominated forest. The closest other population is found in north-central Ohio, over 200 miles away (Conant and Collins 1998; Harding 1997).

Aspidoscelis sexlineata, the Six-lined Racerunner, is a burrowing lizard in the family Teiidae. *Aspidoscelis sexlineata* is a tan to brown lizard with six or seven light stripes on its dorsal surface that may or may not have green on its sides and dorsal surface, depending on subspecies (Conant and Collins 1998; Harding 1997). *Aspidoscelis sexlineata* was not as recently discovered as *D. fuscus*. *Aspidoscelis sexlineata* was discovered in the late 1980's in the state of Michigan; however, very few publications exist to describe this population. *Aspidoscelis sexlineata* are found along a south-facing hillside along Millington Road. The area is composed of sandy soils with sparse and thick grassy vegetation. A few trees are scattered throughout the habitat. The closest other population is found in the Indiana Dunes Region, over 200 miles away (Conant and Collins 1998; Harding 1997).

There is controversy about these populations in Michigan. Could they be glacial relicts or are they simply introduced species? Can these populations sustain themselves? Are they reproducing? Should we protect these populations? These are just a few questions for which

answers are not known. Both populations are found between Murphy Lake Road and Millington Road. In addition to the strange fauna, some strange flora are also found in areas where *D. fuscus* and *A. sexlineata* populations are found. In a personal interview with Fred Case, retired school teacher and orchid expert in the Great Lakes Region (2006), he spoke of two men he met in the woods one day who claimed to be introducing plants and animals to the game area without any sort of documentation. Several of the animals these men supposedly introduced were said to come from Shawnee National Forest, Ohio, and regions of West Virginia. Since we have no documentation of these introductions and no way to contact the men who claimed they were responsible for these introductions, it is most prudent to assume we do not know the origin of the populations. Molecular work would shed some light into where these populations may have originated and whether they could be post glacial relicts. Molecular work was not done in this study; however, molecular work on *A. sexlineata* has begun (Ghada Sharif, personal communication) and collaborations are planned for *D. fuscus*.

Carlson, T. and E. Szuch. 2005. Geographic Distribution. *Desmognathus fuscus fuscus.* Herpetological Review 36(4):461.

DESMOGNATHUS FUSCUS FUSCUS (Northern Dusky Salamander). USA: MICHIGAN: TUSCOLA CO: Murphy Lake State Game Area (43°17'12.9"N, 83°27'13.86"W). 26 September 2004. Collected by Teresa Carlson and Laura Cochran. Verified by James Harding. Michigan State University Museum (MSUM) HE.14494. First state record (Harding 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan). The salamanders were found at two locations along the same stream that were 1.5 mi. apart. Juveniles and adults were found at both locations, demonstrating that there is an extensive breeding range along the stream. Further studies are planned to investigate population size and local distribution, and to determine if population is introduced or represents a possible post-glacial relict.

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Northern Dusky Salamander (Desmognathus fuscus): First State Record, Tuscola County, Michigan, Midwest Fish and Wildlife Conference, Grand Rapids, MI, 12 December 2005

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Northern Dusky Salamander (*Desmognathus fuscus*): First State Record, Tuscola County, Michigan

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On 26 September 2004, two Northern Dusky Salamanders (*Desmognathus fuscus*) were discovered along a stream in Murphy Lake State Game Area (MLSGA), Tuscola County, Michigan. One of the individuals was collected for verification by James Harding from the Michigan State University Museum and deposited there (HE.14494) as the first record of this species in Michigan. MLSGA is a forested region located along an end moraine that is surrounded by mostly agricultural land. The game area also supports the only known population of Six-lined Racerunners (*Aspidoscelis sexlineata*) in Michigan. Initial field observations have demonstrated that *D. fuscus* adults occur throughout the extensive stream system in the game area. Individuals have been found under rocks and logs, both in the water and along the bank, particularly where Eastern Hemlock (*Tsuga canadensis*) occurs. Larvae have also been found in the stream indicating a successfully reproducing and potentially viable population. The closest *D. fuscus* population to the MLSGA population occurs in north central Ohio. Although it has been suggested that the Michigan *D. fuscus* population was introduced, no evidence has been provided to support this conclusion. Preliminary field observations continue and molecular studies are

planned to determine the possible origins of this population. Until it is demonstrated that this population is introduced and is adversely affecting other species of the area, it should be given appropriate protection and MLSGA should be managed accordingly.

Un-Weathered (New) Artificial Cover Objects Effectively Sample Plethodontid Salamanders in Michigan

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Many Plethodontid species are small salamanders with restricted home ranges and are sensitive to natural and human disturbances, making them potential indicators of environmental health and biodiversity (Caro and O'Doherty 1999; Welsh, Jr. and Droege 2001). Since the 1990's, many studies have documented population declines in amphibians, including salamanders, stressing the need for appropriate population monitoring techniques (Blaustein and Dobson 2006; Blaustein et al. 1994; Kohler et al. 2005; Pechmann et al. 1991; Pounds et al. 2006; Young et al. 2004). One such method for monitoring terrestrial salamander populations is the use of Artificial Cover Objects (ACOs).

ACOs cause little disturbance to the environment and require less time, effort and maintenance compared with other monitoring techniques. The repeatability of studies using ACOs and the ability to standardize this technique using number and area of cover objects also makes this method useful (Grant et al. 1992). The Terrestrial Salamander Monitoring Program (TSMP), established in the mid 1990s, recommends ACOs for monitoring terrestrial salamander

populations (Droege 1997). Several studies have attempted to determine the most appropriate way to set up ACOs; however, very few ACO investigations have been done in the Midwestern United States and some specifics of the method are still debated in the literature (Bonin and Bachand 1997; Carfioli et al. 2000; Davis 1997; DeGraaf and Yamasaki 1992; Hyde and Simons 2001; Marsh and Goicochea 2003; Monti et al. 2000; Moore 2005).

The goals of our study were 1) to investigate effectiveness of ACOs to sample terrestrial salamanders in Michigan, 2) to investigate use of aged boards versus new boards and 3) to provide baseline data for *Desmognathus fuscus*, a newly documented species in Michigan (Carlson and Szuch 2005). The TSMP protocol suggests that boards should be placed on bare, leveled soil and weathered for a year before any data are collected (Droege 1997). However, this protocol delays data collection, a potential problem in necessarily short-term surveys. To alleviate this problem, Bonin and Bachand (1997) suggested placing boards on existing wet leaf litter to accelerate the weathering process and reduce the time needed before data can be collected.

In 2004, we set up ACOs at Kresge Environmental Education Center (KEEC) at Fish Lake in Lapeer County, Michigan. KEEC is owned by Eastern Michigan University and consists of 240 acres surrounded mostly by state land. The property consists of one large lake, several small lakes, a tamarack bog, mixed hardwood forests and many kettle ponds. We set up ACOs around a kettle pond surrounded by mostly deciduous forest to determine if there was a preference for aged boards placed on bare, leveled soil or new boards placed on existing wet leaf litter. ACOs consisted of CDX pine plywood (1.9 cm thick) cut to 121.9 cm by 61.0 cm. Size and design of boards were determined during a preliminary study in 2003 that tested four ACO designs of Carfioli et al. (2000). Aged boards were weathered for a year while new boards were

weathered for only two weeks. All boards were placed in the field at the same time to eliminate bias. New boards were placed directly on existing leaf litter with no modification to the ground. Aged boards were placed on the ground after it had been cleared of leaf litter and leveled. Twenty-three pairs of boards were placed equidistantly around the pond approximately 10-12 m apart. Each pair consisted of one aged board and one new board. Within each pair, one board was placed near the pond's edge and the other board was placed 6-8 m upslope from the pond's edge. The location of board type relative to the pond, near or far, was alternated around the pond. ACOs were held in place with aluminum tent stakes and left in the field for two weeks before collecting data. Boards were checked biweekly from 28 April to 12 November 2004. Salamanders found beneath boards were identified to species, measured (SVL) and released at edge of boards.

During the 2004 field season, we observed 154 salamanders: 130 *Plethodon cinereus*, 17 *Ambystoma laterale*, 4 *Notophthalmus viridescens* and 3 *Ambystoma maculatum*. Only data for *P. cinereus* were further analyzed. Without regard to season, *P. cinereus* preferred aged boards placed on bare, leveled soil to new boards placed on existing topography and leaf litter (χ^2 = 20.320, df = 1, $p < 0.05$; Fig. 1). *P. cinereus* preferred boards that were upslope or farther from the pond's edge to boards that were down slope or closer to the pond's edge (χ^2 = 15.820, df = 1, $p < 0.05$); however, no association was found between age and location of board (χ^2 = 3.380, df = 1, $p > 0.05$).

Salamanders were most active in spring (28 April – 8 June 2004) and fall (3 September – 29 October 2004), with fall being the season of greatest activity (Fig. 1). In spring there was no preference for board type (χ^2 = 0.267, df = 1, $p > 0.05$) and in fall, aged boards placed on bare, leveled soil were preferred to new boards placed on existing topography and leaf litter (χ^2 =

21.943, df = 1, $p < 0.05$). Boards that were placed upslope or farther from the pond's edge were preferred in both spring and fall seasons (spring, $\chi^2 = 6.667$, df = 1, $p < 0.05$; fall, $\chi^2 = 7.467$, df = 1, $p < 0.05$). That *P. cinereus* preferred boards placed upslope or away from the pond's edge is not surprising since it has no aquatic larval stage and is not dependent on vernal or permanent ponds for breeding. *P. cinereus* is often found farther from water than many other terrestrial salamanders and avoids areas prone to flooding (Harding 1997; Petranka 1998).

That *P. cinereus* preferred aged boards placed on bare, leveled soil to new boards placed on existing topography and leaf litter corroborates TSMP recommendations; however, if age was the primary factor affecting board use, we would expect little or no use of new boards and significantly more use of aged boards in spring. We would also expect a more equitable use of aged and new boards in fall when both board types would be weathered. Our results suggest just the opposite. There is equal use of aged and new boards in spring and a preference for aged boards in fall. This led us to speculate that something other than age was determining board preference. In spring when conditions are typically cool and humid, both board types may offer suitable conditions for salamanders; however, in fall when conditions are typically warmer and drier, boards placed on bare, leveled soil may create a cooler, more humid micro-environment compared to new boards placed on unleveled ground with existing leaf litter.

In 2006, we tested our hypothesis that there was no preference for aged or new boards when both were placed on bare, leveled soil. Due to the recently discovered population of *Desmognathus fuscus* in Michigan (Carlson and Szuch 2005), we changed our research location to Murphy Lake State Game Area (MLSGA) in Tuscola County, Michigan. MLSGA is composed of 2,645 acres surrounded mostly by agricultural land. Our study site was located in a Hemlock-Northern Hardwoods Forest (Barnes and Wagner 2004) near the northern boundary of

the game area. CDX pine plywood (1.9 cm thick) was cut to 30.5 cm by 61.0 cm. Smaller ACOs were used to better resemble downed woody debris. Boards were placed in pairs containing one aged board and one new board approximately 15 cm apart and each pair of boards was placed approximately 6 m apart. Aged boards were weathered for 2–3 years and new boards were weathered for only two weeks. All boards were placed in the field at the same time to eliminate bias. The site for each board was cleared of leaf litter and leveled before placing the board on the ground. Aluminum tent stakes were used to keep boards in place.

Within the forest community, three adjacent terrestrial sub-habitats were studied: 1) edge of a kettle pond, 2) within the forest proper and 3) along a stream. Thirty pairs of boards were used to sample the three sub-habitats with 10 sites in each sub-habitat. At the pond, half of the sites were placed 2 m from the pond's edge and the other half were placed directly along the pond's edge. In the forest proper, half of the sites were placed along a ridge, while the other half were placed either upslope or down slope relative to the ridge. Along the stream, each pair of boards was placed flush with the edge of the stream bank. Boards were checked biweekly from 12 June to 28 October 2006. Salamanders found beneath boards were identified to species, measured (SVL) and released at edge of boards.

During the 2006 field season, we observed 352 salamanders: 221 *P. cinereus*, 116 *D. fuscus*, 6 *Hemidactylium scutatum*, 6 *A. maculatum* and 3 *A. laterale*. Only data for *P. cinereus* and *D. fuscus* were further analyzed. *P. cinereus* was found in all three sub-habitats: 81 individuals at the pond, 125 individuals in the forest proper and only 15 individuals along the stream. *D. fuscus* was only found along the stream.

Considering all three sub-habitats, *P. cinereus* showed no preference for aged or new boards ($\chi^2 = 0.652$, df = 1, $p > 0.05$, Fig. 2). *P. cinereus* also showed no preference for board age

in either the pond or forest sub-habitat (pond, $\chi^2 = 0.049$, df = 1, $p > 0.05$; forest, $\chi^2 = 1.512$, df = 1, $p > 0.05$). There was also no difference in mean SVL of *P. cinereus* found under aged or new boards (Mean SVL $_{new} = 35.516 \pm 0.695$ mm, Mean SVL $_{aged} = 37.182 \pm 0.552$ mm, $t = 1.973$, df = 184, $p > 0.05$).

For *D. fuscus*, no preference for aged boards versus new boards was found ($\chi^2 = 1.043$, df = 1, $p > 0.05$, Fig. 3); however, mean SVL of individuals found beneath aged boards was greater than mean SVL of individuals found beneath new boards (Mean SVL $_{new} = 31.196 \pm 1.453$ mm, Mean SVL $_{aged} = 35.403 \pm 1.305$ mm, $t = 1.983$, df = 103, $p < 0.05$). No gilled larvae were observed beneath boards, but juveniles as small as 14.7 mm SVL and adults as large as 55.9 mm SVL were observed (Fig. 4).

ACOs are an effective sampling technique for monitoring some species of terrestrial salamanders in Michigan. Six species were found beneath boards during both field seasons; however, only two species were found in quantities large enough for statistical analysis. Ambystomatid salamanders are terrestrial as juveniles and adults but often spend the majority of their lives underground. This behavior may explain why ambystomatids were found in low numbers in our study as well as in studies by Bonin and Bachand (1997) and Grant et al. (1992). *N. viridescens* is primarily terrestrial as a juvenile (eft) and often disperses away from its natal pond during this life-history stage.

The other three species found beneath boards are all terrestrial salamanders that we would expect to find in large numbers beneath ACOs. For two of these species, *P. cinereus* and *D. fuscus*, that was the case in our study. This corroborates findings of Stewart and Bellis (1970) and Carfioli et al. (2000). We are unsure why *H. scutatum* was found in low numbers but

speculate that it is either because they have low population sizes at our study sites or that microhabitat conditions beneath boards were not ideal for this species.

Finding large numbers of *P. cinereus* during both the 2004 and 2006 field seasons was not surprising considering how common this species is throughout the Midwest. It can reach densities as high as 500-9000 per hectare in some parts of its range (Harding 1997; Heatwole 1962). *D. fuscus* was not documented in the state of Michigan until fall 2004 (Carlson and Szuch 2005). An unpublished study by Carlson and Szuch demonstrated that *D. fuscus* in Michigan could be sampled with ACOs placed either in the stream channel or on the stream bank, but not on boards placed 2 m from the stream. Finding such large numbers of *D. fuscus* at MLSGA suggests that the population is well-established and the range of SVLs observed suggests that reproduction is occurring.

In 2006, we tested the hypothesis that age of boards was not the factor affecting board use by terrestrial salamanders and found that when aged and new boards were both placed on bare, leveled soil, there was no preference for either board type. This was observed in both *P. cinereus* and *D. fuscus*. Additionally, we found no difference in mean SVL for *P. cinereus* beneath aged or new boards; however, mean SVL of *D. fuscus* was larger under aged boards. These results suggest that the need to weather boards may be dependent on location, species and goals of the investigation. We found that in Michigan weathering boards is not always needed if the goals of the study are to determine species presence/absence and estimates of abundance; however, if the goal is to determine population age structure, boards may need to be weathered or a variety of board types may need to be used. For *P. cinereus*, weathering does not appear to be needed for studies in Michigan; however, in the case of *D. fuscus*, weathering boards may allow larger individuals to be sampled. Overall, we found that monitoring terrestrial salamander

populations with ACOs in Michigan works well for *P. cinereus* and *D. fuscus*; however, further studies may find ACOs useful for other species.

ACKNOWLEDGMENTS

We thank Melissa Borowiak, Tiffany Fender, Acacia White and students from the 2006 Field Biology and Topics in Ecology Courses at UM-Flint for their assistance in the field. Larry Atherton helped in attaining equipment and supplies. Permission to conduct research at KEEC was granted by Ben Czinski and Eastern Michigan University and at MLSGA by Arnold Karr of the Cass City Office of the Michigan DNR. Funding for this project was provided by the Murchie Memorial Research Fund and Biology Department of UM-Flint. Teresa Carlson was supported (in part) by a Graduate Student Research Assistantship from the Office of Research and Office of Graduate Programs at UM-Flint. This study complied with all applicable state of Michigan land use and scientific collection permits issued by the Michigan DNR and research was conducted under animal use protocol 09427 issued by the University Committee on the Use and Care of Animals of the University of Michigan.

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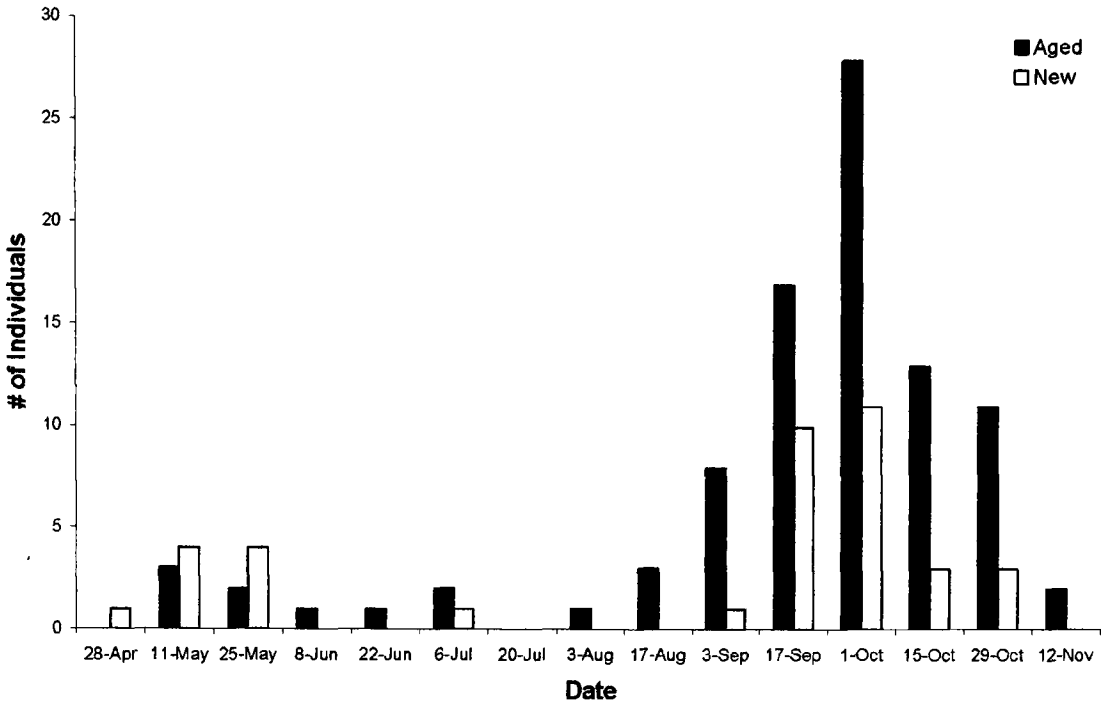

Fig. 1. Number of *Plethodon cinereus* observed beneath aged (weathered) boards placed on bare, leveled soil and new (un-weathered) boards placed on existing topography and leaf litter at Kresge Environmental Education Center, Lapeer County, Michigan in 2004.

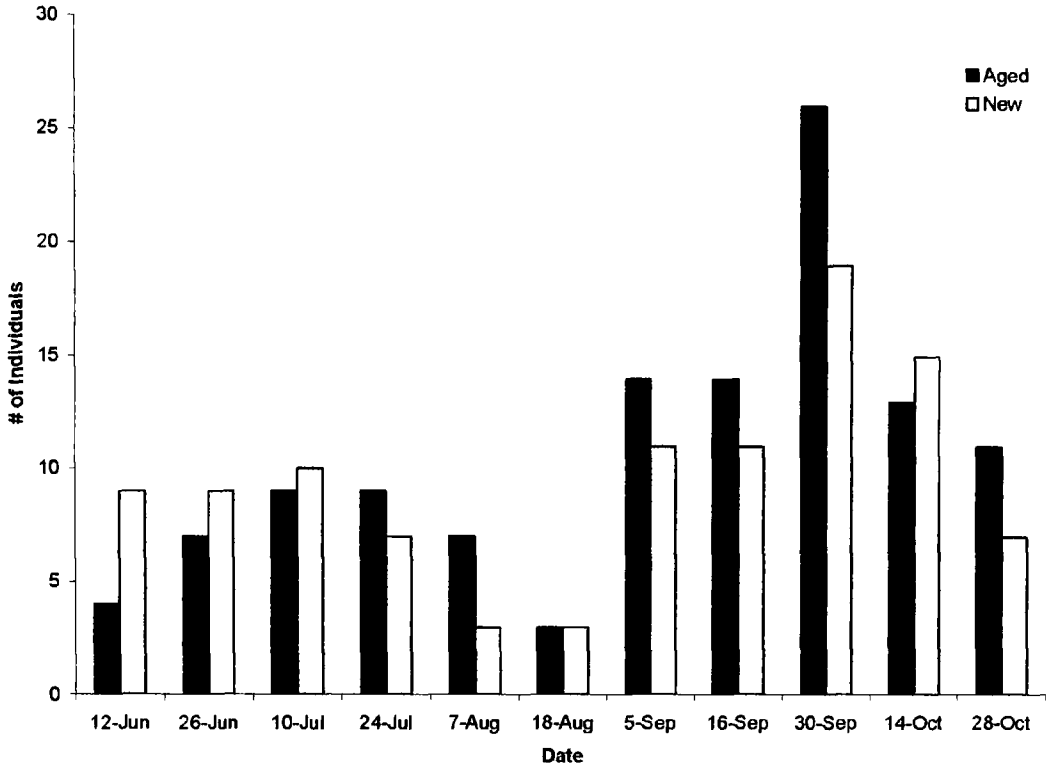

Fig. 2. Number of *Plethodon cinereus* observed beneath aged (weathered) and new (un-weathered) boards placed on bare, leveled soil at Murphy Lake State Game Area, Tuscola County, Michigan in 2006.

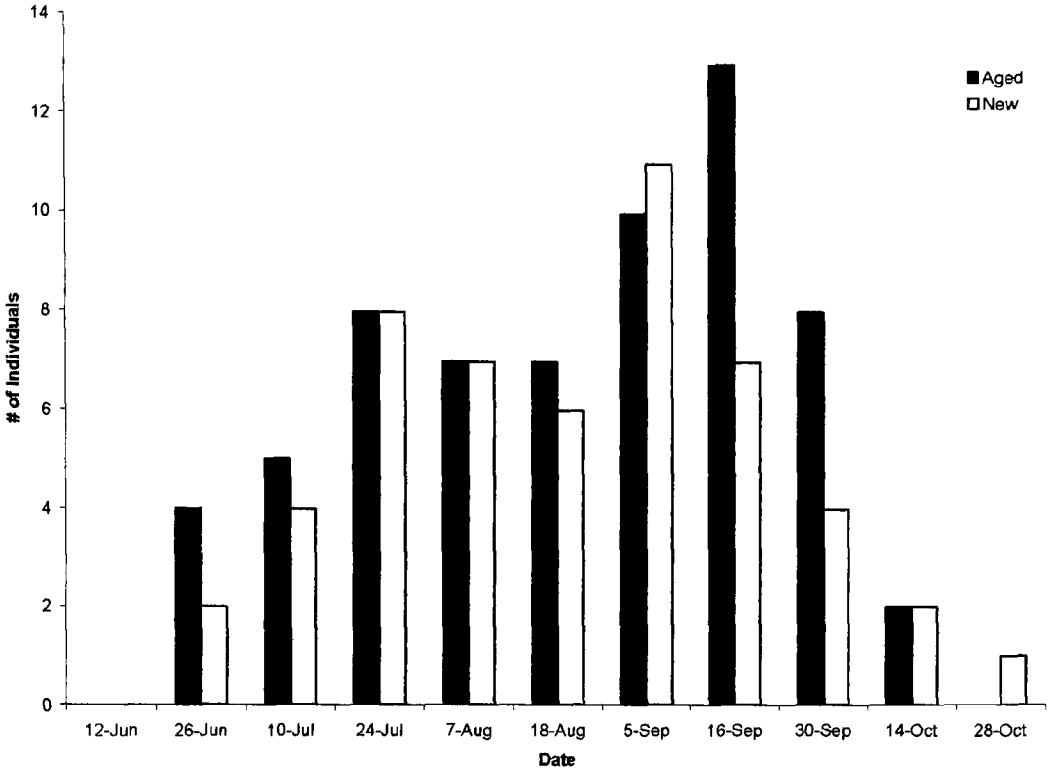

Fig. 3. Number of *Desmognathus fuscus* observed beneath aged (weathered) and new (un-weathered) boards placed on bare, leveled soil at Murphy Lake State Game Area, Tuscola County, Michigan in 2006.

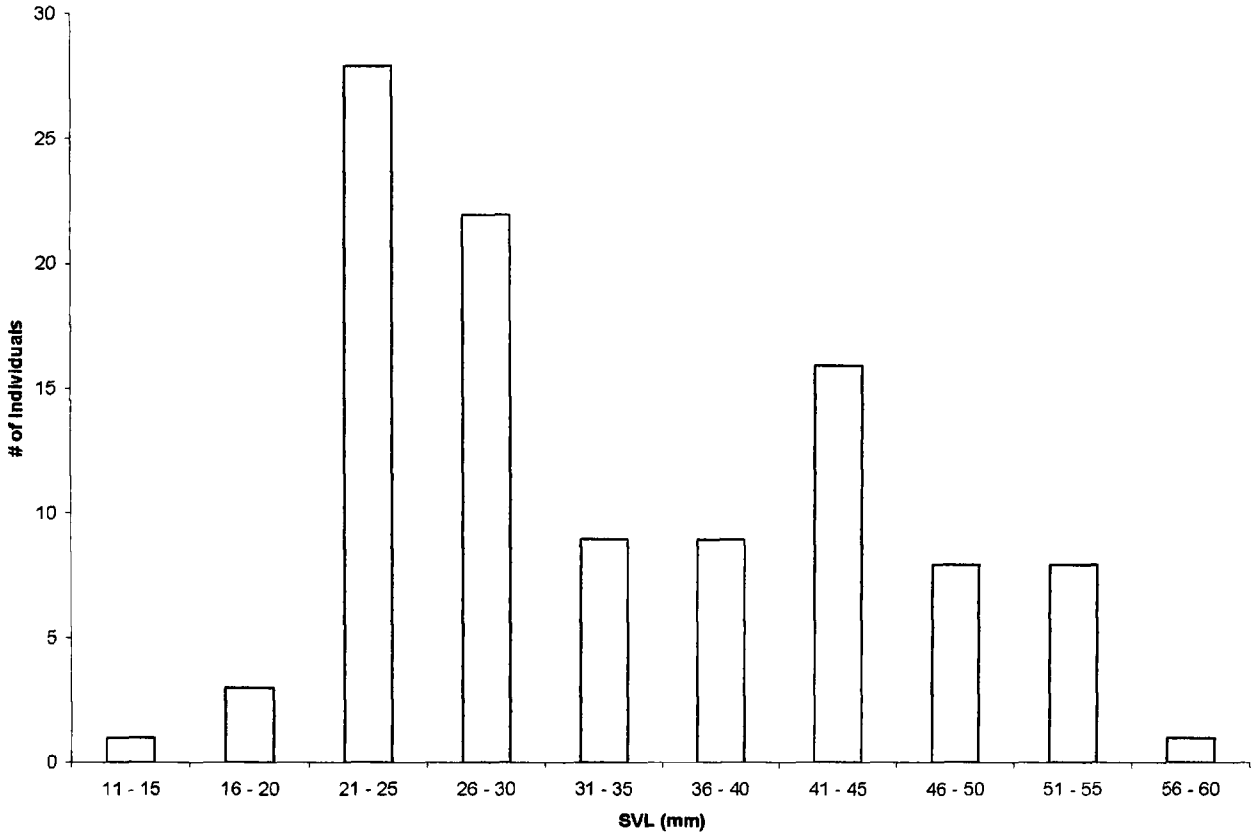

Fig. 4. Number of *Desmognathus fuscus* observed in SVL categories at Murphy Lake State Game Area, Tuscola County, Michigan in 2006.

Aspects of the Natural History of a Disjointed Population of Six-lined Racerunners, *Aspidoscelis sexlineata*, located in Murphy Lake State Game Area, Tuscola County, Michigan

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Introduction

Aspidoscelis sexlineata, the Six-lined Racerunner, is a widely distributed species of lizard in the United States. The range of *A. sexlineata* expands from Florida to Minnesota and from the Atlantic Coast to Wyoming (Conant and Collins 1998). It is found in open, sparsely vegetated habitats and tends to benefit from disturbance (Fitch 1958; Mushinsky 1985). Two subspecies of *A. sexlineata* are recognized. *Aspidoscelis sexlineata sexlineata*, the southern race, ranges from southern Indiana to Florida and from the Atlantic Coast to eastern Louisiana and *Aspidoscelis sexlineata viridis*, a western race, ranges from Minnesota to Texas and from northwestern Indiana to Wyoming. Zones of integration between the subspecies occur in Louisiana, Arkansas, Texas, Oklahoma and Missouri (Conant and Collins 1998). *Aspidoscelis sexlineata sexlineata* has 6 light dorsal stripes and a dark brown or black background color and *A. s. viridis* has 7 light dorsal stripes and a green background color (Conant and Collins 1998; Trauth and McAllister 1996). *Aspidoscelis sexlineata* is late to emerge from and early to retreat to hibernacula, often

only being active for 5 ½ months of the year or less (Clark, Jr. 1976; Etheridge et al. 1983; Fitch 1958; Hardy 1962). In most parts of its range, the natural history of *A. sexlineata* has been thoroughly studied (Bellis 1964; Clark, Jr. 1976; Etheridge et al. 1983; Fitch 1958; Hardy 1962; Hoddenbach 1966; Paulissen 1988; Trauth 1983; Wright and Vitt 1993).

Plestiodon fasciatus, the Five-lined Skink, and *A. sexlineata* are the only lizard species found in Michigan. *Plestiodon fasciatus* is widely distributed throughout the state; however, *A. sexlineata* is only known to occur at one site in the state, with the nearest other population being located in the Indiana Dunes Region, northwestern Indiana. This disjointed population is located in Murphy Lake State Game Area, southern Tuscola County, Michigan. The population was discovered in the late 1980's and has since been listed as a species of special concern for the state of Michigan (Michigan Natural Features Inventory 2007). Research on this population has been very limited and the only published accounts are found within *Michigan Turtles and Lizards* (Harding and Holman 1990) and *Amphibian and Reptiles of the Great Lakes Region* (Harding 1997). Razzano (1999) attempted to determine the origin of this population but results were inconclusive. Basic biological information necessary to make appropriate management decisions are lacking for this population. The goals of this study were to determine subspecies status, describe the population morphologically, determine population characteristics, investigate habitat use patterns, describe seasonal activity patterns and collect biological samples to be used for future molecular analysis.

Methods

Research was conducted at Murphy Lake State Game Area (MLSGA), Tuscola County, Michigan. MLSGA consists of 2,645 acres surrounded mostly by agricultural land. The lizards are found on an open, grassy, south-facing hillside adjacent to a busy road, located near the

northern end of the game area. Habitat occupied by the lizards was approximately one hectare (9,597 m^2).

In 2005 and 2006, visual encounter surveys were conducted to determine population size estimates. Surveys consisted of investigators walking the area occupied by the lizards and recording any lizards observed. The area occupied by lizards was divided into six sections and population size was estimated by combining counts from all sections. All sections were surveyed by one or two observers once weekly or biweekly from June through September of each year. Time of day, age, sex and vegetative cover type were recorded for each lizard observed during surveys. Over-winter hatchling survivorship was calculated using hatchling counts from fall 2005 and 2006 and juvenile counts from spring 2006 and 2007, respectively. Although counts of juveniles in spring 2007 were done to get hatchlings survivorship, data on number of juveniles are not presented.

Drift fences and pitfall traps were used in 2006 and 2007 to gather additional estimates of population size. Six drift fences were set up in the eastern section of the lizard habitat, sampling about 1/3 of the entire area occupied by the lizards. Three fences were placed parallel to the road and three fences were placed perpendicular to the road. Aluminum flashing was used for fencing and 3 ½ gallon buckets were used as pitfall traps. Each fence had one central bucket and two end buckets with 5 meters of fencing between buckets. The central bucket of each fence was 15 meters from the central bucket of the next fence. Drift fences and pitfall traps were used to sample adult lizards on 15 – 18 August 2006, hatchling lizards on 15 – 17 September 2006 and juvenile lizards on 11 – 13 June 2007. Traps were checked every 1 – 2 hours from approximately 1100 h – 1600 h during each day that sampling occurred.

For each lizard captured, snout-vent length (SVL), tail length (TL) and mass were recorded, numbers of light stripes were counted and marking was done by clipping a toe nail. By clipping only a toe nail, marking was temporary and nails would grow back after a short period of time. Head length (HL) was measured for juveniles and adults. Gender was recorded for each adult captured and blood was collected from adults captured during the 15 – 18 August 2006 sample period only. Nails were cut short enough to cause bleeding and blood was stored on Whatman FTA® cards for future molecular analysis. Descriptive statistics for SVL, HL, TL and mass are reported.

Population size estimates were calculated using the Lincoln-Peterson method for hatchlings and the Schnabel method for juveniles and adults (Krebs 1999). SPSS was used to perform a Kruskal-Wallis Test to determine the significance of vegetative cover type use.

Results

All lizards had a green background color. Fifteen hatchlings had 7 light stripes and twenty seven had 8 light stripes or a divided vertebral stripe. All juveniles (N = 13) had seven light stripes. One adult (N = 23) had 6 light stripes and one adult had 8 light stripes, all others had 7 light stripes. Minimum, maximum and mean SVL, TL and mass are given in Table 1 for hatchlings, juveniles and adults. Mean HL of juveniles was 9.70 mm $\pm$ 0.15 mm with a minimum of 8.5 mm and a maximum of 10.5 mm and mean HL of adults was 12.43 mm $\pm$ 0.15 mm with a minimum of 11.4 mm and a maximum of 13.8 mm.

Fifteen females were captured and measured, yielding a mean SVL of 55.18 mm $\pm$ 1.07 mm (Min. = 47.1 mm, Max. = 64.6 mm), mean TL of 105.24 mm $\pm$ 2.44 mm (Min. = 88.7 mm, Max. = 124.0 mm), mean HL of 12.28 mm $\pm$ 0.15 mm (Min. = 11.5 mm, Max. = 13.8 mm) and a mean mass of 5.02 g $\pm$ 0.35 g (Min. = 3.1 g, Max. = 8.1 g). Eight males were captured and

measured yielding a mean SVL of 56.08 mm ± 2.00 mm (Min. = 48.1 mm, Max. = 67.7 mm), mean TL (N = 6; two individuals with broken tail) of 108.17 mm ± 5.68 mm (Min. = 85.5 mm, Max. = 127.5 mm), mean HL of 12.70 mm ± 0.32 mm (Min. = 11.4 mm, Max. = 13.8 mm) and a mean mass of 5.91 g ± 0.66 g (Min. = 4.1 g, Max. = 10.0 g). No significant differences were found between the mean value for males and females for SVL ($t = 2.08$, $p > 0.05$, $df = 21$), TL ($t = 2.09$, $p > 0.05$, $df = 19$), HL ($t = 2.08$, $p > 0.05$, $df = 21$) or mass ($t = 2.08$, $p > 0.05$, $df = 21$). Snout-vent length of hatchlings, juveniles and adults are shown in Fig. 1. Snout-vent lengths of hatchlings and juveniles are normally distributed while snout-vent lengths of adults are bimodal (Fig. 1). Visual encounter survey population size estimates (maximum number of individuals observed) from 2005 and 2006, respectively, yielded 98 and 120 hatchlings, 32 and 60 juveniles and 55 and 53 adults. Over-winter hatchling survivorship was 61.2% and 26.7%, respectively. Population size was additionally estimated using mark-recapture techniques and yielded estimates of 91 hatchlings, 20 juveniles and 51 adults; however, these numbers only represent about 1/3 of the habitat occupied by the lizards. If we were to estimate population size for the entire area occupied by the lizards, above estimates would need to be multiplied by three and we would get estimates of 273 hatchlings, 60 juveniles and 153 adults. Ratios, calculated from maximum day of adult activity for each year, of females to males were 0.731 for 2005 from the day of 29 June and 0.625 for 2006 from the day of 14 June.

Aspidoscelis sexlineata is active from mid-May until late September in Michigan (Fig. 2 and Fig. 3). Juveniles are active from mid-May until they transform into adults in late July, hatchlings are active from early August to late September and adults are active from mid-May to early September. First hatchlings were found on August 9, 2005 and August 7, 2006.

Recruitment from juvenile to adult age/size classes was extremely low in both 2005 and 2006 (Fig. 2 and Fig. 3).

Aspidoscelis sexlineata was found in 4 habitat types: bare/sparse vegetation, thick vegetation, tree/forested areas and beneath objects. Significant differences were found in vegetative cover type use ($\chi^2 = 15.85$, df = 3, $p < 0.05$). Bare/sparse vegetation was the most commonly used vegetative cover type, followed by thick, treed and then beneath objects ($Median_{sparse/bare} = 27$, $Median_{thick} = 23$, $Median_{tree/forested} = 8$, $Median_{beneath\ objects} = 1$). Additional species found in the lizard habitat during visual encounter surveys include: *Thamnophis sauritus*, *Thamnophis sirtalis*, *Storeria dekayi*, *Lampropeltis triangulum*, *Plethodon cinereus*, *Bufo americanus*, *Rana sylvatica*, *Rana pipiens*, *Hyla versicolor*, *Peromyscus* spp. and *Zapus* spp.

Discussion

Aspidoscelis sexlineata has been thoroughly studied throughout most of its range; however, studies on the population in Michigan are lacking. The Michigan population is a single disjointed population that is listed as a species of special concern (Michigan Natural Features Inventory 2007). This is one of the first studies to collect basic natural history data on this small, disjointed population.

Since forty-nine out of seventy-eight individuals (63 %) had 7 light dorsal stripes on a green background color, the Michigan population is most likely the *A. s. viridis* subspecies, or western race, of the species. The closest populations of this race are found in northwestern Indiana and up into Wisconsin and Minnesota. Twenty-eight individuals (36 %) had what appeared to be 8 light stripes or a divided vertebral stripe. Variation in number of stripes is common among this species (Trauth 1980). SVL is often larger in females than males and TL

and HL are often larger in males than females; however, this pattern was not found in the Michigan population. This result may be from the low number of individuals sampled (15 females and 8 males) or some natural variation found within this population. Capturing and measuring more individuals would aid in determining the cause for this anomaly. Finding more males than females in this population could be a result of the sampling time. Maximum counts for both years were found during June when females could be laying eggs; therefore, may not be as visible as males. Additionally, maximum SVL, TL and HL are low compared to other populations sampled by Trauth (1980). SVL estimates (67.7 mm) are lower than all states measured except Iowa (66 mm) and TL (124.0 mm) and HL (13.8 mm) are lower than all states sampled (lowest TL = 146 in Kansas and Indiana and lowest HL = 14.6 in Colorado) in Trauth (1980). Smaller sizes were found in SVL, TL and HL for the Michigan population of *A. sexlineata*; however, this pattern is not surprising since Michigan is a northern population where the activity season is shorter compared to other parts of its range. Figure 1 shows a bimodal curve for snout-vent lengths of adults suggesting that juveniles and smaller adults survive in low frequencies; however, if they do survive beyond a certain SVL they often survive into late adulthood. One reason for this pattern may be that juveniles and small adults get pushed to less ideal regions within the habitat which would make survival less likely. This pattern of juveniles and small adults being pushed to less ideal peripheral regions of the habitat was found in studies by Hardy (1962). If juveniles and small adults survive until more suitable habitat can be occupied, survivorship to late adulthood appears to be likely. Hatchlings have a smaller body size and larger surface area to volume ratio which causes the hatchlings to heat and cool faster and may lead to behavioral changes such as later activity seasons. Hatchlings were active for

almost a month later than adults in the Michigan population, a pattern also seen in populations found in Indiana and Illinois (Alan Resetar, personal communication).

Presence of hatchlings indicates that reproduction is occurring within the Michigan population. Survivorship of hatchlings seems to vary by year. In 2006, it was 61.2 % and dropped to 26.7 % in 2007. The true estimate is probably somewhere in the middle of these two numbers and stochastic events from year to year are probably the cause for such extreme variations. Poor feeding conditions for hatchlings, fueling up before winter, or a hard frost could potentially lower the winter survivorship. In a Texas population (hatchlings, juveniles and adults) 16% of the population survived one winter (Clark, Jr. 1976). Considering that Texas has milder winters than Michigan and that we found survivorship percentages greater than 16% for hatchlings alone, this population appears to be surviving the winters well. Recruitment from juvenile to adult age/size classes was found to be extremely low. Low survivorship of juveniles and young adults and low recruitment rates suggest this population could be at carrying capacity and unless more suitable habitat is available, the population size will not expand but will remain stable or decline.

In a recent study by Kapfer and Pauers (2006), activity patterns for a Wisconsin population of *A. sexlineata* were found to range from May to August and hatchling activity may even last until October. Similar patterns were found in this study. Adults were active from late May to early September and hatchlings were found active into late September.

The Michigan population of *A. sexlineata* does not appear to be impacting other animal species within the community. Several other species were found within the lizard habitat; however, none of these species seem to be a direct competitor. *Plestiodon fasciatus*, the other lizard found in Michigan, occupies more forested areas than *A. sexlineata*; therefore, they are

unlikely to compete with one another (Harding 1997). No *P. fasciatus* were found in the habitat occupied by *A. sexlineata*. Other studies have found potential predators of *A. sexlineata* to include: box turtles, collared lizards, racers, corn snakes, rattlesnakes, rat snakes, king snakes, hog-nosed snakes, copperheads, skunks, raccoons, blue jays and hawks (Fitch 1958; Hardy 1962). Potential predators at our sight were similar and included garter snakes (*Thamnophis sirtalis*), ribbon snakes (*Thamnophis sauritus*), milk snakes (*Lampropeltis triangulum*), blue jays and hawks. Although never seen due to their nocturnal behavior, skunks and raccoons were probably also present.

Aspidoscelis sexlineata uses bare/sparse vegetation and thick vegetation more than any other vegetative cover type. The Michigan population of *A. sexlineata* appears to be at carrying capacity; therefore, maintaining or even expanding the habitat suitable for *A. sexlineata* is critical for Michigan's species of special concern. Lizards occur along a south-facing hillside that could easily be maintained as open, sparsely vegetated habitat. It may even be useful for humans to maintain this early succession habitat since there are utility poles that run parallel along the habitat occupied by the lizards. If normal roadside maintenance does not maintain the area in an early succession stage, cuttings or burning may need to be used in order to do such. Blood was collected and molecular work is currently being done to determine whether this population is a post-glacial relict or an introduced species (Ghada Sharif, personal communication). Molecular work will aid in determining what management for this population is needed.

Acknowledgements

I thank Melissa Borowiak, Courtney Ostipow and Acacia White for their assistance in the field. I thank Arnold Karr, Wildlife Biologist, Cass City Field Office, and the Michigan Department of Natural Resources for permission to conduct research at Murphy Lake State Game Area. James

Harding, Ernest Szuch and Dennis Viele provided advice and support. Funding for this project was provided by the Dean's Office of the College of Arts and Sciences and the Biology Department at UM-Flint. I was supported (in part) by a Graduate Student Research Assistantship from the Office of Research and Office of Graduate Programs at UM-Flint. This study complied with all applicable state of Michigan land use and scientific collection permits issued by the Michigan DNR and research was conducted under animal use protocol 09463 issued by the University Committee on the Use and Care of Animals of the University of Michigan.

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	Snout-Vent Length (mm)			Tail Length (mm)			Mass (g)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Hatchlings (N = 44)	28.9	37.9	33.70 ± 0.32	45.6	65.4	55.09 ± 0.75	0.6	1.5	1.03 ± 0.04
Juveniles (N = 13)	36.2	48.3	41.10 ± 0.83	59.9	83.3	69.91 ± 2.14	1.5	2.5	1.94 ± 0.08
Adults (N = 23; For TL, N = 21)	47.1	67.7	55.49 ± 0.96	85.5	127.5	106.08 ± 2.32	3.1	10.0	5.33 ± 0.33

Table 1. Minimum, maximum and mean snout-vent length, tail length and mass for hatchling, juvenile and adult *Aspidoscelis sexlineata* in Murphy Lake State Game Area, Tuscola County, Michigan.

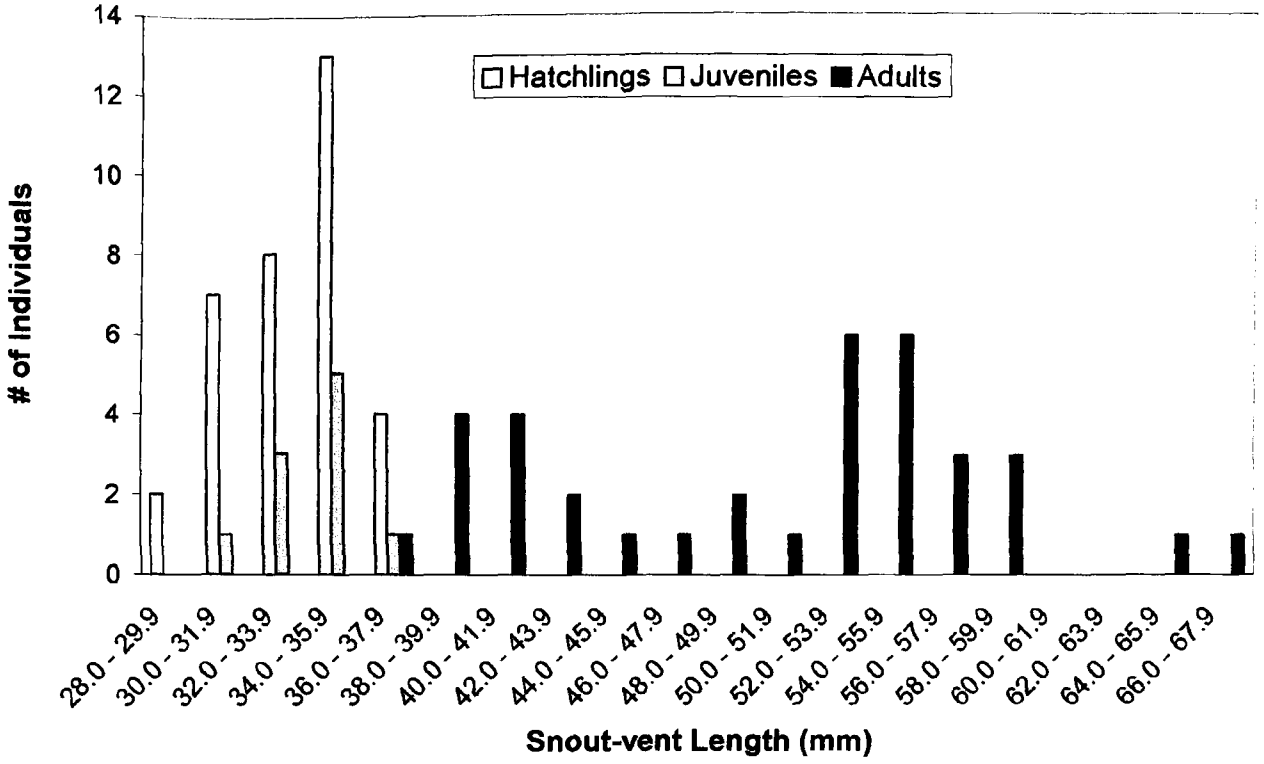

Fig. 1. Snout-vent length of *Aspidoscelis sexlineata* found at Murphy Lake State Game Area, Tuscola County, Michigan.

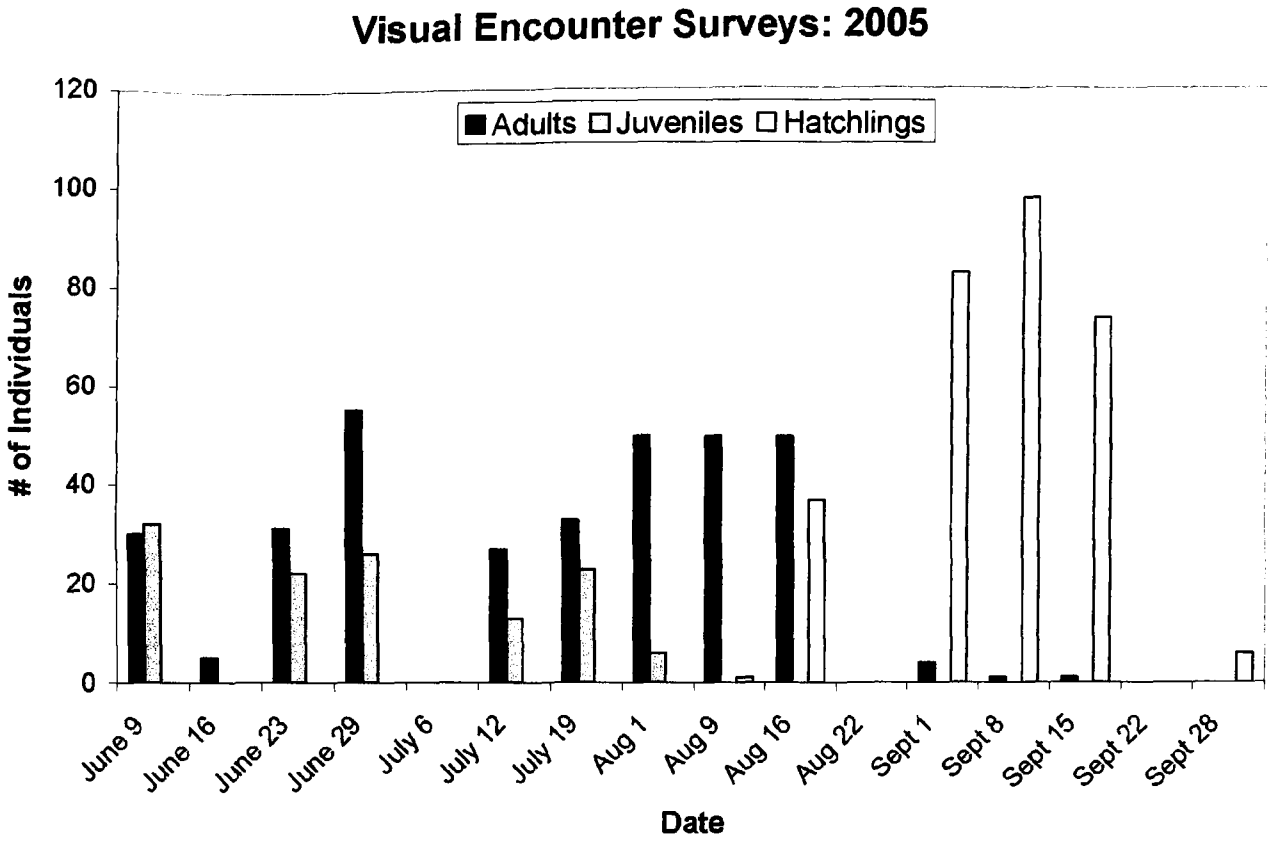

Fig. 2. Number of *Aspidoscelis sexlineata* found during visual encounter surveys at Murphy Lake State Game Area, Tuscola County, Michigan from June to September 2005.

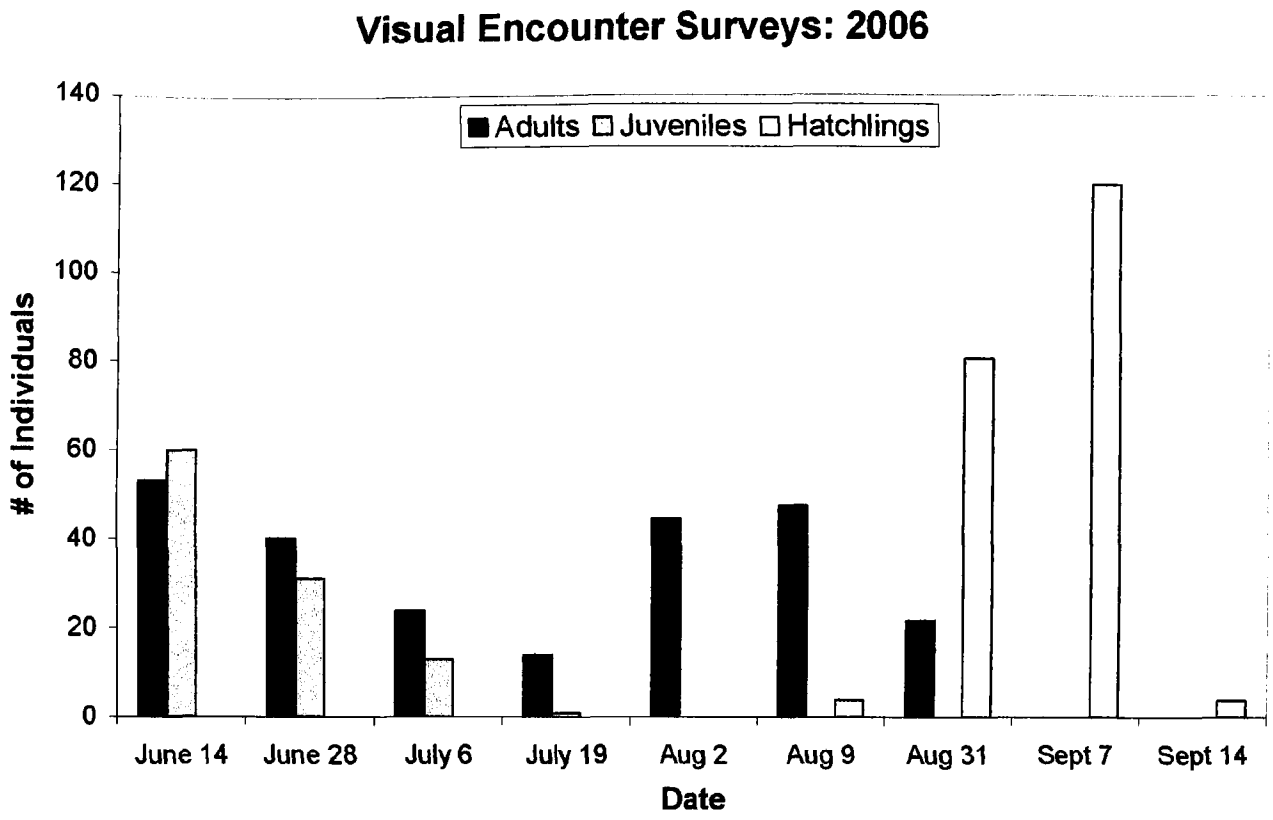

Fig. 3. Number of *Aspidoscelis sexlineata* found during visual encounter surveys at Murphy Lake State Game Area, Tuscola County, Michigan from June to September 2006.

DISCUSSION

Murphy Lake State Game Area is a unique patch of land not like many others in the southern-lower peninsula. MLSGA is a forested oasis within an agricultural region. It has a variety of habitats including Hemlock-Northern Hardwoods Forests, which are very common in northern Michigan but quite rare in southern Michigan and Grasslands, which are becoming a rare landscape almost everywhere (Barnes and Wagner, Jr. 2004; Murphy Lake State Game Area Strategic Plan 2004). The fauna of MLSGA includes the only known populations of *Desmognathus fuscus* and *Aspidoscelis sexlineata* in Michigan. Additional species of herpetofauna sighted during field work are listed in Appendix A.

In fall 2004, *D. fuscus* was first documented in the state of Michigan (Carlson and Szuch 2005). Since then, we have learned that *D. fuscus* is limited to stream-side habitats located between Murphy Lake Road and Millington Road. Adults, juveniles and hatchlings were found indicating that the population is reproducing. *Desmognathus fuscus* populations can be sampled by using artificial cover objects along the stream. The ACOs imitate downed logs along the stream and the age of the board may be important depending on the location of the study and the purpose of the study. Larger individuals of *D. fuscus* are found under aged boards. *Plethodon cinereus* is found along the streams occupied by *D. fuscus* but in very low numbers.

Aspidoscelis sexlineata has been documented in the state since the late 1980's, yet virtually no information is available on this population (Harding 1997; Harding and Holman 1990; Michigan Natural Features Inventory 2007). Based on morphological observations, the population appears to be the prairie subspecies, *Aspidoscelis sexlineata viridis*. Population size estimates are well over 450 individuals for the entire area occupied by the lizards. Hatchling survivorship seems to vary widely by year. The active period for this population is longer than is

listed in most references but seems to coincide with other northern populations (Harding 1997; Kapfer and Pauers 2006). All vegetative types within the area occupied by the lizards were used; however, bare/sparse vegetation and thick vegetation were used more frequently than any other vegetative cover type. Potential competitors and predators were rarely found in the area.

Should these two unique herpetofaunal populations be given special status? These populations are unique to the state of Michigan but it is not known from where these populations came. Are they introduced or are they post-glacial relict populations? Someone could have brought some salamanders and/or lizards to Michigan from another state and dropped them off at Murphy Lake State Game Area; however, this would take some knowledge of both species. *Desmognathus fuscus* are found along streams and when they are uncovered they quickly try to escape. *Aspidoscelis sexlineata* are known for being fast; they use speed to escape predators. The person would have had to catch some salamanders or lizards, including at least one male and one female. Then he/she would have to introduce them into the right habitat to ensure survival and reproduction. On the other hand, Murphy Lake State Game Area does provide some unique habitats rarely found in southern Michigan. MLSGA is part of a glacial feature called a moraine that is formed by the accumulation of rock debris from a glacier that often consists of a topographically varied landscape with sand and gravel (Easterbrook 1999). MLSGA has unique plant communities like Hemlock-Northern Hardwoods and Grasslands with *Yucca sp.* and *Opuntia sp.* present on the lizard hillside. Could the salamander and lizard populations be just a unique feature of this landscape? Maybe MLSGA provided the right habitat for their survival.

Molecular work has begun for *A. sexlineata* (Ghada Sharif, personal communication) and collaborations are planned for *D. fuscus*. Molecular work will minimally tell us whether we are dealing with populations from the Great Lakes Region or whether they are southern or western

populations. If the populations are closely related to the Great Lakes Region populations, then they could be post-glacial relicts or introduced. There is no way to know for sure. If the populations are from southern or western populations, then we can most likely rule out the possibility that they are post-glacial relicts and assume they are introduced.

Whether *D. fuscus* and *A. sexlineata* are introduced or not, may not matter. Both populations are disjointed by several hundred miles from the next nearest population of the same species, so no immigration or emigration is occurring (Conant and Collins 1998; Harding 1997). With enough time, these populations could form their own lineage and speciation could occur. Additionally, these species appear to occupy niches not utilized by other species in Michigan. *D. fuscus* occupies stream-side habitats not occupied by other salamanders in Michigan. Michigan's other salamanders are forest or pond-dwelling species (Harding 1997). *Aspidoscelis sexlineata* occupies open, grassy habitats that are not occupied by the only other species of lizard in Michigan, *Plestiodon fasciatus*. *Plestiodon fasciatus* occupies more forested habitats, so competition between the two species is unlikely. Additionally, if they are an introduced species, we have a natural laboratory already designed to study introduced species.

With this in mind, I recommend that *D. fuscus*, the Northern Dusky Salamander, and *A. sexlineata*, the Six-lined Racerunner, be managed and protected. If we cannot conclusively refute the idea that these populations are post-glacial relicts, then protection and management should be continued on these populations until we can conclusively refute that idea. If the populations are found to be introduced, further studies should be done to determine whether they are causing negative effects on other populations.

Managing these populations would require very little in addition to what is already done. Concerns for the *D. fuscus* population would include the possibility of forest cutting and clearing

or local farming practices leading to increased siltation or pesticides/fertilizers leaching into the stream. Cutting is not in the management plan for Murphy Lake State Game Area and farming practices have not seemed to impact the population thus far (Murphy Lake State Game Area Strategic Plan 2004). Concerns for *A. sexlineata* include loss of habitat due to succession or pesticide treatment to roadsides. *Aspidoscelis sexlineata* prefers bare/sparse vegetation or thick vegetation and rarely uses forested regions. The south-facing road-cut occupied by the lizards is starting to get smaller because saplings and small trees are filling the hillside. Taking out some trees to maintain habitat for this species would be advised and it may also provide benefits to humans since there are power lines running parallel with the lizard habitat. Protecting both populations from collection by adding *D. fuscus* to the species of special concern list and keeping *A. sexlineata* on the species of special concern list, at least until molecular work can be completed, would help assure these populations are managed and maintained until further evidence can be presented as to whether they are native, post-glacial relicts or non-native, introduced species.

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Appendix A.

The following is a list of additional sightings from Murphy Lake State Game Area:

Scientific Name	Common Name
Notophthalmus viridescens	Eastern Newt
Ambystoma maculatum	Spotted Salamander
Ambystoma laterale	Blue-spotted Salamander
Plethodon cinereus	Red-backed Salamander
Hemidactylium scutatum	Four-toed Salamander
Bufo americanus	American Toad
Pseudacris triseriata	Western Chorus Frog
Pseudacris crucifer	Spring Peeper
Hyla versicolor	Eastern Gray Treefrog
Rana clamitans	Green Frog
Rana sylvatica	Wood Frog
Rana pipiens	Northern Leopard Frog
Chelydra serpentine	Common Snapping Turtle
Emydoidea blandingii	Blanding's Turtle
Chrysemys picta	Midland Painted Turtle
Nerodia sipedon	Northern Water Snake
Regina septemvittata	Queen Snake
Thamnophis sirtalis	Eastern Garter Snake
Thamnophis sauritus	Northern Ribbon Snake
Storeria dekayi	Brown Snake
Pantherophis spiloides	Central Rat Snake
Lampropeltis triangulum	Eastern Milk Snake

Of these species, *Emydoidea blandingii* and *Pantherophis spiloides* are listed as species of special concern within the state (Michigan Natural Features Inventory 2007).