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KANAB AMBERSNAIL AND OTHER TERRESTRIAL SNAILS IN SOUTH CENTRAL UTAH

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ABSTRACT.—Surveys for succineid snails were conducted to improve genetic and geographical information for the endangered Kanab ambersnail (*Oxyloma haydeni kanabensis* Pilsbry) and related taxa within the Succineidae. Surveys were carried out in the Bureau of Land Management Kanab District, at the Grand Staircase–Escalante National Monument, on 3 private holdings, and along Highways 89, 12, and 14, all in south central Utah. A population of Kanab ambersnails was known to exist in the region; other populations of *Oxyloma* were discovered in primarily seep-fed wetlands in Kanab Creek and in tributaries of and wetlands along the Virgin, Sevier, and Escalante rivers in Kane, Garfield, and Piute counties. None of the newly discovered populations was identified as Kanab ambersnail on the basis of anatomical evidence, although one was at the type locale for that species. We list other snail species encountered and discuss the status of the Kanab ambersnail in light of recent genetic research.

Key words: ambersnail, taxonomy, Colorado Plateau, Oxyloma, *Succineidae.*

In North America succineid snails (Mollusca: Stylommatophora: Succineidae) are often, but not invariably, terrestrial and are associated with a variety of wetland habitats. Although they have been widely collected and described, identification of succineid specimens can be difficult, and taxonomy within Succineidae is in flux, owing, in some cases, to anatomical similarity of species (e.g., Franzen 1981, 1985, Frest and Dickson 1986, Hoagland and Davis 1987, Miller et al. 2000, Stevens et al. 2001) and in other cases also to conflicting results from anatomical and genetic studies (Hoagland and Davis 1987, Miller et al. 2000, Stevens et al. 2001). New species descriptions and expansions of known ranges are ongoing in North America (Harris and Hubricht 1982, Franzen 1983, 1985, Frest and Dickson 1986, Spamer and Bogan 1993a, 1993b). Currently, 2 species in the family (Kanab ambersnail, *Oxyloma haydeni kanabensis* Pilsbry, and the Chittenango ovate ambersnail, *Succinea chittenangoensis* Pilsbry) are federally endangered.

In the southwestern U.S., succineid collections are patchy (e.g., Ferriss 1910, Chamberlin and Jones 1929, Baily and Baily 1952, Bequaert and Miller 1973, Hovingh 1993, Kerns 1993, Spamer and Bogan 1993a, 1993b). In 1992 the Kanab ambersnail was listed as federally endangered (U.S. Fish and Wildlife Service 1992) after searches at the type locality in Kanab Canyon, near Kanab, Utah, located only 3 individuals (Clarke 1991) and the owner of the only other known site for the species (in Three Lakes Canyon also near Kanab) began plans to develop the property. During the listing process, a 3rd population was discovered in Grand Canyon, Arizona (Spamer and Bogan 1993a, 1993b); all 3 populations were included in the listing. Since listing, 2 additional populations of *Oxyloma* have been located in Grand Canyon (at Indian Gardens along South Bright Angel Trail, and at 9-Mile Marsh along the edge of the Colorado River); both were identified on the basis of anatomy as *O. h. haydeni* Binney (Stevens et al. 1997, Miller et al. 2000).

In his reclassification of *O. h. kanabensis* (originally *Succinea hawkinsi* Baird), Pilsbry (1948) indicated that the new subspecific status should be regarded as preliminary and that full species status might be warranted. No further work on taxonomy of southwestern succineids was undertaken until after listing of the Kanab ambersnail. Results of preliminary molecular taxonomic work with the Grand Canyon *O. h. haydeni* and *O. h. kanabensis* populations and the remaining *O. h. kanabensis* population on private land in southern Utah were inconsistent with anatomical results (Miller et al. 2000). Here we report on surveys

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undertaken to improve understanding of succineid distribution in south central Utah and to provide specimens for further taxonomic study.

MATERIALS AND METHODS

Surveys

We conducted surveys in the Bureau of Land Management's (BLM) Kanab District; in the Grand Staircase–Escalante National Monument (also BLM land); and on private land in Three Lakes Canyon, in Kanab Canyon, and on The Nature Conservancy's Autumn Buttercup Preserve in the Sevier drainage in Garfield County. Additional public rights-of-way, all in south central Utah (Fig. 1), were also surveyed, i.e., along Highway 89 in the Sevier and Virgin drainages, along Highway 12 near the northern boundary of the monument, and along the east end of Highway 14. In all cases we briefly described riparian and seep-fed wetlands and systematically searched them for live or recently dead snails. Succineids from several sites were collected for genetic analysis reported elsewhere (Stevens et al. 2001).

Survey of Kanab Canyon followed the August 1998 discovery of an *Oxyloma* population in the canyon containing the type locality of Kanab ambersnail (Meretsky and North 2000). Survey efforts extended from the dam at the Kanab City Reservoir north to the confluence with Red Canyon (a straight-line distance of 11.2 km) and included the area believed to be the type locality for *O. h. kanabensis.*

Following discussions with BLM personnel and helicopter surveys of potential habitats for succineid snails, we determined survey locations in Grand Staircase–Escalante National Monument. Ground surveys were conducted primarily from Skutumpah Road, Highway 12, and Cottonwood Canyon Road. The monument contains many small patches (<< 100 m in any dimension) of potential habitat and considerable fenced land; not all potential habitat was visited. *Oxyloma* specimens from one site in Upper Valley died before being preserved but we did not re-collect from the site as a sample was collected and successfully preserved from a nearby site along the same drainage.

The Nature Conservancy's Autumn Buttercup Preserve, north of Panguitch in Garfield County, was surveyed in response to reports of *Oxyloma* there (Lunceford personal communication). Surveys along Highways 89 and 14 were conducted where wetland vegetation could be reached in the public rights-of-way.

In 1996 and 1998 we conducted surveys of Three Lakes; surveys in the remainder of Kane County and in Garfield County were conducted in 1999. Two sites, one in Piute County and the other in Garfield County (below the Burr Trail), were visited in 2000; Burr Trail specimens, which were collected after anatomical identifications had been completed, are identified only to genus. All other *Oxyloma* were identified to species by Shi-Kuei Wu of University of Colorado (no geographical information was supplied so that identifications were purely on the basis of anatomy); *Catinella* were not identified with certainty and are recorded only at the genus level; other snails were identified by Eric North. Specimens were archived at Northern Arizona University's Laboratory of Quaternary Paleontology and at the Museum of Northern Arizona, both in Flagstaff.

Population Estimation

Population estimation was undertaken at Three Lakes, where the Kanab ambersnail was known to be present, and in Kanab Canyon, the type locality for the Kanab ambersnail (although snails there were later identified by anatomy as belonging to other taxa). Snails were counted in haphazardly placed 20-cm-diameter circles in appropriate habitat; we dispersed samples throughout the habitat but did not grid the sites to allow true random sampling.

Habitat in Kanab Creek was too extensive to sample every patch; an initial estimate of snail density was constructed by sampling in several different wetland patches, stratified by habitat type (e.g., wet meadow, cattail stand). Using GPS equipment, we measured or surveyed areas of habitat patches, categorized them by habitat type, and calculated population estimates from the median densities of the initial sample of similar wetlands. Final estimates considered only snails ≥4 mm in length, as these were considered to be equally observable by all surveyors and in all habitats and to be somewhat more likely to survive to adulthood (7 mm; Wu personal communication) than smaller snails. Snails in streamside vegetation along Kanab Creek were not included

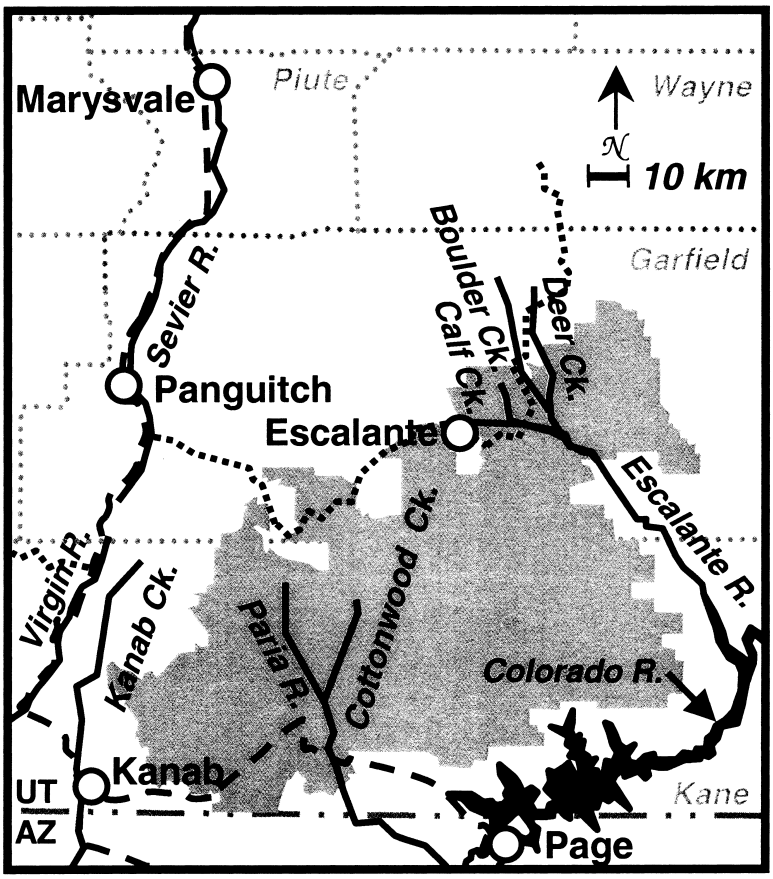

Fig. 1. Study area in south central Utah. Black dashed lines represent Highway 89 (long dashes), Highway 14 (short dashes west of Highway 89), and Highway 12 (short dashes east of Highway 89). Shaded area is Grand Staircase–Escalante National Monument.

in the population estimates because the creek undergoes major flooding during monsoon rains. We expected mortality rates to be high in these habitats and excluded snails there (which were present only in comparatively very low densities) to provide more conservative estimates of population size. Additional details on estimation techniques are given in Meretsky and North (2000). We surveyed habitat area in Three Lakes and used 30 samples from each of 3 habitat types to extrapolate total population size.

RESULTS

Surveys

Succineids were found, primarily in spring- or seep-fed habitats, along the Virgin, Sevier, and Escalante rivers and their tributaries, in Kanab Creek (but not in its surveyed tributaries), in isolated wetlands near Henrieville Creek (along Highway 12), in Harris Flats (along Highway 14), and at a pond north of Calf Pasture Point (Table 1). At least 4 succineid taxa from 2 genera (*O. h. haydeni*, *O. h. kanabensis*, *O. retusa*, *Catinella* spp.) and 14 other species from 12 genera were found alive or recently dead: *Cochlicopa lubrica* (Müller), *Discus cronkhitei* (Newcomb), *Euconulus fulvus* (Pilsbry), *Gyraulus circumstriatus* (Tryon), *Hawaiia minuscula* (Binney), *Nesovitrea electrina* (Gould), *Pupilla muscorum* (Linnaeus), *P. sonorana* (Sterki), *Sonorella* sp., *Vallonia cyclophorella* (Sterki), *Vertigo ovata* (Say), *Vitrina limpida alaskana* (Dall), *Zonitoides arboreus* (Say), and *Z. nitidus* (Müller). Some sites supported only succineids, and no site that contained other snails lacked succineids.

TABLE 1. Locations of snail surveys in south central Utah, with snail species located and habitats present. Agency designations for public lands indicate Grand Staircase–Escalante National Monument (GSENM), non-monument Bureau of Land Management lands (BLM), Dixie National Forest (DNF), and State of Utah (UT). Species designations within *Oxyloma* are based on anatomy. Habitat in rights-of-way (RoW) was not measured. Locations are based on the WGS84 datum.

County	Agency	Description	Lat	Long	Species and habitat
Kanab Creek and tributaries					
Kane		Kanab Canyon, upper bench near road	37° 08.58′	112° 32.46′	*Oxyloma retusa*, marsh and wet meadow, grazed.
Kane		Kanab Canyon, Big Lake (upper bench)	37 09.47	112 32.70	*O. retusa*, marsh and wet meadow, grazed.
Kane	part BLM	Kanab Creek near dam, S end of survey of lower bench	37 04.63	112 32.41	(next line)
Kane	part BLM	Kanab Creek S of Red Cyn, N end of lower bench survey	37 10.05	112 32.21	*O. h. haydeni, Vertigo ovata, Euconulus fulvus, Z. arboreus, Nesovitrea electrina*. Willow, marsh, wet meadow, wetland forb vegetation, some grazing. Total surveyed Kanab Canyon habitat approx 67,000 m^2.
Kane		Three Lakes, north lake in Three Lakes Canyon	37 08.26	112 34.01	*O. h. kanabensis, Discus cronkhitei, Vertigo ovata, N. electrina, Gyraulus circumstriatus, E. fulvus*. Marsh, wet meadow, and wetland forb vegetation, some grazing. Total habitat at north lake approximately 1200 m^2.
Kane	BLM	Hog Cyn (to 3 hr up from Kanab Ck)	37 05.33	112 30.86	No snails, less than 1500 m^2 of wet meadow habitat.
Kane	BLM	Trail Cyn (coordinates are confluence)	37 04.10	112 32.37	No snails, no wetland habitat.
Kane	BLM	Red Cyn (coordinates are confluence)	37 10.61	112 32.22	No snails, no wetland habitat.
Kane	UT/BLM	Water Cyn (coordinates are confluence with Cottonwood Ck)	37 04.19	112 36.96	No snails, no wetland habitat.
Virgin River and tributaries					
Kane		Below KOA campground N of Glendale	37 22.94	112 34.62	*O. retusa*, willow, wet meadow in RoW.
Kane		Hidden Lake outflow	37 20.71	112 36.09	*O. h. haydeni*, marsh, wet meadow in RoW.
Kane		Virgin River N of Glendale	37 20.06	112 36.13	*O. h. haydeni*, wet meadow in RoW.
Other Kane County sites					
Kane		1 km W of Long Valley Jn on Hwy 14	37 29.44	112 31.31	No snails, no wetland habitat.
Kane	DNF	S of Hwy 14, 6 km W Long Valley Jn	37 29.29	112 33.69	No snails, water present.
Kane	DNF	Harris Flats on Hwy 14	37 29.51	112 34.33	*Catinella* sp., water present.
Kane	DNF	Harris Flats on Hwy 14	37 29.67	112 34.72	*Catinella* sp., water present.

Oxyloma h. haydeni and *O. retusa*, but not *O. h. kanabensis*, were found in Kanab Creek (Table 1). *Oxyloma h. haydeni* was identified from 2 collecting sites on the lower bench, which ranges from less than a meter to somewhat over a meter above Kanab Creek at base flow. We identified *Oxyloma retusa* from 2 sites on the upper bench, approximately 30 m above Kanab Creek. *Oxyloma h. haydeni* and *O. retusa* were also found in the Virgin River drainage, and *O. retusa* was found in the Sevier and Escalante watersheds. *Catinella* occurred along the Sevier and Escalante rivers and their tributaries, at isolated springs within Grand Staircase–Escalante National Monument, and along Highway 14.

Of 26 sites from which snails were absent, 10 supported no wetland habitat. Grazing occurred at several sites without snails; however, grazing also occurred at sites that supported diverse snail assemblages, although these tended to be larger sites or complexes of sites. Wetland vegetation types containing snails included willow stands (*Salix* spp.), marsh vegetation (generally cattails and bulrushes: *Typha* spp., *Scirpus* spp., and *Schoenoplectus* spp.),

TABLE 1. Continued.

County	Agency	Description	Lat	Long	Species and habitat
Sevier River and tributaries					
Garfield	TNC	Sevier River Preserve, Utah Nature Conservancy	37 57.22	112 24.93	*O. retusa, Hawaiia minuscula, E. fulvus* found in wet meadow that extends beyond the property. No grazing, but fire recently used for management.
Garfield		Sevier River near mile marker 121.3 on Hwy 89	37 57.30	112 24.71	*Catinella* sp. in wet meadow in RoW.
Garfield		Mammoth Creek, near mile marker 114.5 on Hwy 89	37 42.59	112 23.50	*Catinella* sp. in wet meadow in RoW and adjacent unfenced property.
Garfield		Asay Creek, at Hwy 89	37 35.05	112 28.59	*Catinella* sp., *Vertigo ovata, Pupilla sonorana* in wet meadow in RoW.
Piute		6.4 km N of Marysvale on Highway 89, Sevier backwater	38 29.54	112 14.84	*O. haydeni* found in sparse marsh vegetation in RoW.
Grand Staircase–Escalante National Monument and vicinity					
Escalante River and tributaries					
Garfield	GSENM	Lower Calf Creek Falls to campground	37 49.72	111 25.17	*O. retusa, Catinella* sp., *Cochlicopa lubrica, P. muscorum, Zonitoides nitidus, Sonorella* sp. found near falls. Willow, wet meadow, and wetland forbs.
Garfield	GSENM	Escalante River from Hwy 12, surveyed to 4 km west of hwy	37 46.53	111 25.41	*O. retusa, Catinella* sp. found in wetland near confluence with Calf Creek in <1000 m^2 of wet meadow.
Garfield	GSENM	Dry Hollow Ck to Boulder Ck near Escalante, N end of survey	37 50.44	111 25.05	*Catinella* sp., *Vitrina limpida alaskana, P. sonorana, Vallonia cyclophorella, Z. arboreus* found in sparse, fringing wet meadow.
Garfield	GSENM	Dry Hollow Ck to Boulder Ck near Escalante, S end of survey	37 48.56	111 23.10	(previous line)
Garfield	GSENM	Escalante River east of Boulder Creek	37 45.58	111 20.38	No snails, small, flood-prone tributary.
Garfield	GSENM	Deer Ck, S of Burr Trail	37 51.15	111 21.32	*Oxyloma* sp. in approx. 10,000 m^2 of wet meadow.
Garfield		Allen Ck/Upper Valley	37 43.04	111 47.05	*O. retusa* in sparse wet meadow in RoW.
Garfield		South Hollow/Upper Valley	37 41.12	111 48.66	*Catinella* sp. in RoW.
Garfield	GSENM[1]	Birch Ck/Upper Valley	37 45.71	111 41.47	*Oxyloma* sp., *Catinella* sp. in wet meadow in RoW.
Garfield	DNF	Garden Spring	37 42.13	111 50.55	*Catinella* sp., water present.

wet meadow vegetation (generally rushes and sedges: *Juncus* spp. and *Carex* spp.), and wetland forbs (generally watercress and cutleaf water-parsnip: *Nasturtium officinale* and *Berula erecta*).

Population Estimates

The populations of *Oxyloma* in Kanab Canyon were concentrated in the habitat between approximately 2 km north of Highway 89 bridge and 1 km below Red Canyon. In summer 1999 the Kanab Canyon *Oxyloma* population was estimated at 1.52 million snails ≥4 mm, with approximately 1.35 million on the lower bench and 170,000 on the upper bench. Although the upper and lower bench collections each contained only a single species, one upper bench site known to contain *O. h. retusa* flows down to the lower bench, and wetland vegetation occurs along much of the short connecting stream. Given the area of habitat involved (over 52,000 m^2 on the lower and

TABLE 1. Continued.

County	Agency	Description	Lat	Long	Species and habitat
Paria River and tributaries					
Garfield		Paria River E of Cannonville	37 33.68	112 02.67	No snails, dry meadow.
Garfield	GSENM	NE of Henrieville Springs	37 36.27	111 54.61	*O. retusa*, wet meadow in RoW.
Garfield	GSENM	Unnamed spring NE of Henrieville	37 35.83	111 58.71	No snails, 75 m^2 of wet meadow.
Garfield	GSENM	Unnamed spring NE of Henrieville	37 35.88	111 57.06	No snails, wet meadow in RoW.
Kane	GSENM	Unnamed spring in Cottonwood Cyn, near campground	37 19.45	111 53.01	No snails, 150 m^2 of marsh. Flood prone.
Kane	GSENM	Unnamed spring in Cottonwood Cyn, approx 7 km N of Hackberry Cyn	37 19.81	111 53.02	No snails. 400 m^2 of marsh and willow, very flood prone.
Kane	GSENM	Lower 3 km of Hackberry Cyn (lat-long is confluence with Cottonwood Cyn)	37 15.42	111 54.60	No snails, willow and *Tamarisk* habitat, but very flood prone.
Kane	GSENM	Pump Canyon Spring	37 20.73	111 52.47	No snails, no wetland habitats, grazed.
Other springs in or near GSENM					
Kane	GSENM	Unnamed spring below Harry Colwes Spring, S end of 50-Mile Mountain	37 14.86	111 08.33	No snails, <500 m^2 of wet meadow, grazed.
Kane	GSENM	Lake Pasture in Lake Draw, 50-Mile Mountain	38 17.46	111 08.49	No snails, approx. 5000 m^2 of wet meadow and wetland forbs, grazed.
Kane	BLM	Slide Canyon, 3 km outside GSENM	37 20.77	112 16.26	No snails, <3000 m^2 of wet meadow, grazed.
Kane	GSENM	Pond N of Corral Canyon, N of Calf Pasture Point	37 22.64	112 10.21	*Catinella* sp. near pond in marsh, wet meadow. Incompletely surveyed due to nesting raptors.
Kane	GSENM	Adam Springs	37 22.05	112 09.68	No snails, no wetland habitats seen.
Kane	GSENM	First Point Spring	37 15.61	112 19.99	No snails, 5 m^2 of wet meadow, grazed.
Kane	GSENM	Old Corral Spring	37 16.09	112 19.73	No snails, 150 m^2 of wet meadow, grazed.
Kane	GSENM	Unnamed water reserve	37 17.02	112 18.47	No snails, no wetland habitat.
Kane	GSENM	Unnamed spring along Red Breaks	37 16.45	112 18.34	No snails, no wetland habitat.
Kane	GSENM	Seaman Spring	37 07.14	112 14.69	No snails, 2800 m^2 of willow, marsh, and wet meadow.
Kane	GSENM	Unnamed spring; BLM calls "Brown"	37 12.47	112 10.29	No snails, 100 m^2 of wet meadow, grazed.
Kane	GSENM	Unnamed spring	37 12.08	112 12.09	No snails, wet meadow, grazed.
Kane	UT	Cottonwood Spring	37 15.08	112 18.95	No snails, no wetland habitat.

[1]On monument border.

over 15,000 m^2 on the upper bench), the likelihood of more than one taxon on at least the lower bench was too large to ignore. Thus, we do not specify population size at the species level. Snails were found primarily in seep-watered willow, marsh, wet meadow, and herbaceous wetland vegetation on the lower bench and in seep-watered marshes and wet meadows on the upper bench.

The upper lake in Three Lakes Canyon contained the most extensive and accessible habitat for Kanab ambersnails on that property. The population of *O. h. kanabensis* there was estimated to include approximately 180,000 snails >1 mm in length in June 1998, before the major reproductive period. Additional habitat (less, in total, than the approximately 1220 m^2 at the upper lake) was available at and between the other lakes. Ambersnails were observed in cattails and wet meadow vegetation, as well as in stands of buckbean (*Menyanthes trifoliata*).

DISCUSSION

Our results indicate that succineid snails are more common in south central Utah than previously reported, although Chamberlin and Jones (1929) list many locations for succineids farther north. Even small (<600 m^2) wetland

habitat patches can harbor these snails. Although vegetation differed among the various wetlands that contained succineids, occupied areas consistently provided unusually stable hydrologic conditions in this desert region. Sandstone aquifers and their associated seeps and springs were often key to this stability.

Although several streams in the area are permanent (e.g., the Virgin and Escalante rivers, Calf, Boulder and Kanab creeks) and might be expected to support snail populations in their riparian zones, occasionally they are subject to large floods, particularly during monsoon rains. Periodic floods generally scour vegetation, rework streambeds, and move considerable sediment (e.g., Webb et al. 1992), actions likely to eliminate all snails in strictly riparian vegetation; we found no snails in flood-prone areas that lacked refugia (e.g., backwaters or seep-fed vegetation out of the flood zone). Stevens and Meretsky (1997) reported that all *O. h. kanabensis* inundated by floodwaters at Vasey's Paradise in Grand Canyon in 1996 were swept away by water or knocked from vegetation by floating debris. In addition, several local streams are at least 1 m below their banks at base flow, so that only xeroriparian vegetation and woody riparian vegetation occur along the banks. Utah biologists searched the East Fork of the Virgin River and reported only xeric and flood-prone habitats there and no succineids (Webb and Fridell 2000).

Kanab Ambersnail

The current understanding of succineid taxonomy is incomplete. Pilsbry (1948) and Franzen (1963, 1964) suggested that anatomy of the genus *Oxyloma* could be quite variable; and yet anatomy has, until recently, been the only taxonomic tool available, and published species descriptions are based on anatomy. Preliminary genetic studies of *Oxyloma* have revealed apparent discrepancies between anatomical and genetic information (Miller et al. 2000, Stevens et al. 2001). Specifically, individuals from the 2 populations identified as *O. haydeni kanabensis* appear, on the basis of genetic data, to belong to different taxa. Thus, this endangered taxon, as it is presently legally understood (on the basis of peer-reviewed taxonomy), is composed of 2 populations that are not closely related (Miller et al. 2000). Endangered status cannot be reviewed until new peer-reviewed taxonomic classifications are published; however, studies to support reclassification have yet to be undertaken. Taxonomic discrepancies also may exist within *Catinella* (Stevens et al. 2001).

The location of the type locale for the Kanab ambersnail is not entirely clear from written records. Ferriss described the location simply as "The Greens, 6 m[iles] above Kanab on Kanab Wash," and added that snails were "found on a wet ledge among the moss and moccasin (cypripedium) flowers" (personal communication to Pilsbry, 1910).

Prior to the 1880s, Kanab Creek in Kanab Canyon was a small stream running through a large, wet meadow with a high water table (Webb et al. 1992). During the 1880s a series of catastrophic floods, probably aided by overgrazing, cut the streambed down 20–30 m, leaving a series of separate wet meadows watered by springs along an upper bench and exposing a lower series of springs just above the current level of Kanab Creek. This double-benched landscape with an entrenched stream has remained relatively unchanged since approximately the time that Ferriss made his original collection. The development of wetland vegetation at that time is unclear, but grazing was almost certainly widespread; the present major landowner in the snail-inhabited reach does not permit grazing in most of the wetlands, and so lower-bench habitat is likely more extensive now. However, water is currently withdrawn by pipe directly out of the rock at several locations at the back of the upper bench, reducing and/or eliminating the wet meadows that would have been present there in Ferris' time.

One person who grew up in the area recalled that the name "The Greens" was used for the entire seep-fed section of the canyon. Others identified this as a more specific area of wet meadow or meadows on the west side of Kanab Creek, on the upper bench. A member of a family that owned a portion of the canyon indicated the name applied most specifically to a particular upper-bench meadow that still contains *Oxyloma retusa.* This location is approximately 6 miles (9.6 km) above the town of Kanab in Kanab Canyon. Ladyslipper orchids (*Cypripedium* sp.) mentioned by Ferriss do not currently grow there, and none have ever been reported in Kane County (Welsh et al. 1993). However, the helleborine orchid (*Epipactis gigantea*), which has a somewhat similar

flower, is relatively common in Kanab Canyon. Local movie filming in the 1960s further disturbed this particular canyon (N. Cram personal communication), and a cattle tank and diversion pipes have been added more recently.

The meadow specifically identified as "The Greens" is approximately 350 m from the site Clarke (1991) searched when the Kanab ambersnail population in Kanab Canyon was reported as consisting of only a few individuals; it is 200 m from a lower-bench site from which *O. h. haydeni* was collected in 1998 and 1999 from a population estimated at over a million, and 350 m from the nearest upper-bench site containing *O. retusa.* Of snails collected in the region in the past 10 years and identified on the basis of anatomy, only snails from Three Lakes have been identified as *O. h. kanabensis* (Wu personal communication). Three Lakes is approximately 2 km from Kanab Canyon, and outflow from Three Lakes and nearby springs formed a tributary to Kanab Creek until the tributary was piped for the town of Kanab in the early 1900s (Robinson 1970).

When Clarke surveyed Kanab Canyon for *O. h. kanabensis,* he was apparently unaware that Pilsbry and Ferriss (1911) reported not only *Succinea hawkinsi* (reclassified in 1948 by Pilsbry as *O. h. kanabensis*), but also *Succinea retusa* (later *O. retusa*) from "The Greens." Thus, it is not clear which taxon Clarke found in small numbers in 1991; the specimens were not subject to anatomical evaluation. Spamer and Bogan (2002) suggested that this 2nd taxon, *O. retusa,* was recorded in error, but the confirmation of *O. retusa* in the present day suggests otherwise.

Unfortunately, the anatomical identification of *O. retusa* was made after the genetic studies reported in Stevens et al. (2001) were completed. No individuals of Kanab Canyon populations identified as *O. retusa* were included in that study, although individuals identified anatomically as *O. retusa* from other sites were included, as were individuals from the lower bench of Kanab Canyon (identified as *O. h. haydeni)* and from Three Lakes (identified as *O. h. kanabensis*). These specimens, apparently from 3 species, all appeared to cluster as a single genetic group that is distinct from the Grand Canyon population identified as *O. h. kanabensis* (Stevens et al. 2001). The confusion of geographical, historical, anatomical, and genetic information leaves us with little certainty on any front. The justification for an endangered *Oxyloma* subspecies in south central Utah, or even for a distinct *Oxyloma* taxon there, has been called into question. Additional genetic research may, in time, clarify first the taxonomic and then the legal standing of this perplexing group.

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