Two Gynandromorphs of *Ixodes scapularis* (Acari: Ixodidae) from New York State

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ABSTRACT Gynandromorphism, the simultaneous occurrence of both male and female genotypic and morphological characteristics in a single individual of a normally sexually dimorphic species, is rare in ticks. The phenomenon is documented previously for free-living specimens representing several tick genera, particularly *Amblyomma* and *Hyalomma*, but only rarely in *Ixodes*. Here we describe the first two known gynandromorphs of the blacklegged tick, *Ixodes scapularis* Say, collected while flagging vegetation during routine tick surveillance in the Hudson Valley region of New York State. Uniquely, both specimens display some morphological features typical of nymphs, in addition to those of both males and females.

KEY WORDS *Ixodes scapularis*, gynandromorphism, tick morphology, blacklegged tick, neoteny

Gynandromorphism in ixodid ticks is uncommon, but the phenomenon has been extensively reviewed (Schulze 1933, Campana-Rouget 1959, Buczek 1993, Simões et al. 1993). Approximately 77 naturally occurring cases have been documented, with the vast majority (83%) of recognized gynandromorphic individuals belonging to the genera *Amblyomma*, *Hyalomma*, or *Rhipicephalus* (Pavlovsky 1940, Pavlovsky and Bernadskaya 1948, Labruna et al. 2002, Keskin et al. 2012). To date, only five gynandromorphs have been reported in the genus *Ixodes*; these include single specimens each of *Ixodes dentatus* Marx (Smith 1942), *Ixodes ricinus* (L.) (Tovornik 1987), *Ixodes holocyclus* Neumann (Doubé 1974), and two specimens of *Ixodes pacificus* Cooley and Kohls (Keirans and Lane 1997). A teratologic female specimen of *I. ricinus* reported by Zapletal (1957) probably is not a gynander, although some later authors list it as such, following Campana-Rouget (1959), who tentatively mentioned the tick in her discussion of gynandromorph types.

Here we describe what we believe to be the first two known gynandromorphs of the blacklegged tick, *Ixodes scapularis* Say.

Materials and Methods

Host-seeking *I. scapularis* were collected from shrubby understory vegetation bordering public hiking trails during standardized flagging surveys previously described (Prusinski et al. 2014) and conducted by the New York State Department of Health (NYSDOH) as part of routine statewide tick surveillance. Ticks collected were maintained alive and identified to species at the NYSDOH Vector Ecology Laboratory, using a standard key (Keirans and Clifford 1978). Upon discovery, the two gynandromorphs were preserved in 80% ethanol and submitted to the United States Department of Agriculture's National Veterinary Services Laboratories (NSVL, accession numbers 13-038660 and 14-038264) for further examination and confirmation of their preliminary identifications. Multiple photographic images were made of each specimen at different focal lengths under incident lighting, using a dissecting microscope fitted with a digital camera (Models Z16 APO and KY-F75U, respectively, Leica Microsystems GmbH, Wetzlar, Germany). Congruent source images were electronically combined to yield single pan-focal images, using the software package Auto-Montage Pro version 5.04.0013 (Synoptics Ltd., 2006). Both specimens are retained in the NVSL parasitology reference collection.

Results

Gynandromorph specimen 1 was collected at large on 18 October 2013, from a State historic site (N42.08186, W-073.9155) in southeastern Columbia County, New York. One hour of flagging by two NYSDOH employees at this location also yielded 96 female and 103 male *I. scapularis*.

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Overall, the specimen is the size (idiosomal length = 1.8 mm) of a small male *I. scapularis* (Keirans et al. 1996) and predominantly light tan in color, including the legs. At first glance, the general contours and proportions of the tick suggest a very tiny, pale, unengorged female *I. scapularis*, but one with excessive areas of darkly sclerotized or pigmented cuticle both dorsally and ventrally. Leg dimensions (lengths, diameters) relative to the size of the idiosoma are more nearly those of a typical female than a male, and most strikingly, the palps are typically female in relative size and shape. Setal vestiture of the body is female-like, appearing shorter and somewhat sparser than that of a typical male, relative to the size of the specimen.

Dorsally (Fig. 1A), the brown, sclerotized shape of a normal female scutum is discernible, but the posterior margin is indistinct. This margin transitions into an ill-defined alloscutum, a partly sclerotized part of which occupies an area approximately matching that of the female scutum, equally brown, and with fragmented, irregular margins. Ventrally (Fig. 1B), the cuticular grooves are those typical of an unfed female, except that the genital groove extends anteriorly as far as the posterior extent of coxae II, as it typically does in males. The genital aperture is at the level of coxae III, as in normal males, and although it is a bit narrower than normal, its structure seems otherwise male-like, including some brown, sclerotized margins. Female *I. scapularis* typically display little sclerotization and pigmentation in the cuticle of the ventral idiosoma, but this gynandromorph shows several other brown areas, approaching those of typical males. It has a distinct pregenital plate (reduced in size and elliptical, rather than the typical campaniform shape), flanked anteriorly on either side by the usual pair of small, sclerotized lateral plaques mesad of their respective coxae I. The anterior half of what would be the median plate in a male *I. scapularis* is brown, with a diffuse, irregular posterior margin that breaks up into fragmented patches of color on the untanned cuticle that scarcely extend posteriorly on one side into what would normally be the adanal plate of a male. Coarse punctations usually present on the male ventral plate are absent in the ventral sclerotized area of specimen 1. Cuticular areas that would be bilateral sclerotized epimeral plates in a typical male both show some minor brown sclerotization medial to the spiracular plates. Both spiracular plates are essentially round, as in typical females, except that the left one is slightly drawn out both anteriorly and posteriorly, possibly suggesting the elongate, oval shape of a male plate. All of the coxa are male-like (internal spurs on coxae I are missing).

The posterior margins of the basis capituli, both dorsally and ventrally, seem to blend the typical contours of both male and female *I. scapularis*. The ventral basis (Fig. 2B) is much like that of a typical male, except that the usual spur-like postero-median marginal projection is greatly muted. Additionally, the posterior ends of the ridge-like auricularae are slightly extended, suggesting a rudimentary retrorse spur not present in either sex of the adult, but typically present in nymphs. Dorsally (Fig. 2A), the basis shows a pair of small, female-like

cornua, but it has no porous areas. Finally, the hypostome (Fig. 2B) seems to combine and display features typical of male, female, and even nymphal *I. scapularis*. This hypostome extends anteriorly about three-fourths the length of the adjacent female-like palps, whereas the hypostomes of female and nymphal *I. scapularis* typically are approximately coextensive with their respective palps, and the hypostome of a typical male may be coextensive or slightly shorter than its fore-shortened palps. The overall shape of the specimen 1 hypostome most resembles that of a normal nymph, including its margins tapering to an acute apex, whereas typical adult hypostomes are sexually dimorphic, widest in the middle and bluntly rounded apically (females), or broad throughout and blunt or slightly bilobed apically (males). The base of the hypostome is broad, most like that of a typical male. Dentition reflects both male and female influences, and the usual files and rows of denticles—or even individual denticles—are not clearly defined. Apically, the denticular rows may contain either three or four points on either side, but at their bases, most flow together to form crenulate rows and resemble the structures seen on male hypostomes. More basally on the hypostome, a few of the denticular points are incompletely independent, as well, and the indistinct rows may be either two or three denticles wide on either side. Discounting the corona, the hypostome has about seven rows of denticles, with a smooth transition from smallest points apically to largest basally. That arrangement is unlike those of either females or nymphs, but it follows the pattern of male *I. scapularis*, with the paired basolateral denticles the largest on the hypostome. In our specimen 1, however, these two basal denticles are relatively acute compared with the typical rounded apices on those of males.

Gynandromorph specimen 2 was collected at large on 20 October 2014, from a State historic site (N42.21068, W-073.832996) in eastern Columbia County, New York, approximately 17 km north of the site where specimen 1 was collected. One hour of flagging by two NYSDOH employees at this location also yielded 80 female and 88 male *I. scapularis*.

Overall, specimen 2 is remarkably similar to specimen 1, with the following notable exceptions. The idiosomal length is slightly greater, at 1.9 mm, but still small for any adult *I. scapularis*. The legs again seem largely female-like, except that the first pair is barely hypertrophied and proportionally closer to those seen in typical male specimens. In general first impression, specimen 2 looks again like a very small, unengorged female, with extra patches of darkened cuticle both dorsally and ventrally, but its legs are more distinctly sclerotized and typically darkened than those of specimen 1. The palps, in perspective to the rest of the body, look female-like, elongate relative to their width, but the evident ratio of length to width is somewhat less than in specimen 1, i.e., tending slightly toward the male condition. Dorsally (Fig. 1C), specimen 2 differs little from specimen 1, except that the marginal groove of the idiosoma and the thus-demarcated marginal body fold are more distinct, especially in the caudal

Fig. 1. Gynandromorphic *I. scapularis*. Specimen 1. (A) Dorsal habitus. (B) Ventral habitus. Specimen 2. (C) Dorsal habitus. (D) Ventral habitus. Scale bars = 0.5 mm.

region, where the groove is barely discernible. Ventrally (Fig. 1D), again, specimen 2 differs little from specimen 1, other than in the haphazard extent, margins, and shapes of the various designated sclerotized areas. Both spiracular plates are slightly drawn out caudally from the typically subcircular female shape into a vague lengthwise oval, but far from the distinctly elongate form of a male plate.

The basis capituli of specimen 2 compares favorably to that of specimen 1, both dorsally (Fig. 2C) and ventrally (Fig. 2D). However, the ridge-like margins of typical adult auriculae are greatly attenuated, except posteriorly, where they are produced into a pair of

distinct retrorse spur-like points (Fig. 2D), as in nymphs, but perhaps half as long. The hypostome (Fig. 2D), again presents as an unusual amalgam of male, female, and nymphal traits. In specimen 2, compared with the palps, its length is more nearly coextensive, but its apex is less acute than that in specimen 1. The general hypostome shape is nymph-like, and dentition again shows the smallest denticles apically, with a gradual increase in size toward the basal, largest pair of denticles. However, few denticles on specimen 2 are distinctly independent, with nearly all fused basally to others in their rows, forming crenulated ridges more like those typically present on male hypostomes.

Fig. 2. Capitulum of gynandromorphic *I. scapularis*. Specimen 1. (A) Dorsal aspect. (B) Ventral aspect. Specimen 2. (C) Dorsal aspect. (D) Ventral aspect. Scale bars = 0.1 mm.

Discussion

According to the [Campana-Rouget \(1959\)](#) classification system for tick gynandromorphs, both of our specimens would be best characterized as complete mosaic types because their morphological features are a complex, blended mixture of male and female phenotypes, with no symmetrical dominance of one over the other in any somatic area. Our specimens thus seem to

follow the pattern set in observations of earlier examined gynandromorphs of *Ixodes* spp. ([Smith 1942](#), [Doubé 1974](#), [Tovornik 1987](#), [Keirans and Lane 1997](#)) in that nearly all display a disorderly amalgam (mosaic) of male and female morphological characteristics throughout the individual. Of the previously known specimens, only the *I. ricinus* of [Tovornik \(1987\)](#) was not a mosaic, and only that tick and the two *I. pacificus*

described by Keirans and Lane (1997), like ours, were collected directly from the natural environment. Our two specimens seem to be unique, however, in the neonenic display of some features on the capituli that reflect characteristics of the nymphal stage of development. This unusual condition also may be reflected in the notably small body size of both of our gynandromorphic specimens.

The scientific literature on *I. scapularis* is vast, reflecting intense research interest due to its capacity to transmit at least six known zoonotic pathogens to humans, including bacterial, protozoan, and viral agents. Hundreds of thousands, if not millions, of adult *I. scapularis* have been collected across the geographic range of this species in the United States and individually identified during ecological research and public health investigations. The NYSDOH alone has collected and identified >42,100 adult *I. scapularis* since 2002 as part of routine tick population monitoring and tick-borne pathogen surveillance, and an additional 39,161 adult *I. scapularis* clinical samples were submitted from 1991–2011 for examination by the NYSDOH Tick Identification Service passive tick surveillance system. No other gynandromorphic specimens were identified in these New York studies. Roughly comparable statistics were reported by Tovornik (1987), who examined ~50,000 specimens of a closely related tick species, *I. ricinus*, from the former Yugoslavia but found only one gynandromorph among them. Similarly, the U. S. Department of Agriculture's National Tick Surveillance Program (NTSP, currently centered at the NVSL in Ames, Iowa) has operated since 1961, offering tick identification services on a national basis. During that time, the NTSP has examined and processed ~1.25 million tick specimens (comprising all submitted species and all life stages). Among them were more than two dozen gynandromorphs in several genera, but within the uncounted thousands of adult *I. scapularis* from throughout the geographic range of this tick, no gynandromorph was encountered. Thus, to our best knowledge, based upon personal experience and the lack of reports in reviewed tick literature, this is the first record of field-collected gynandromorphic *I. scapularis*, and such specimens evidently are extremely rare in nature.

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