Ticks and mites parasitizing free-ranging reptiles in Austria - with an identification key to Central European herpetophagous Acarina

Field studies conducted in Central Europe revealed that up to 75% of the free-living reptile specimens were parasitized by hard ticks of the family Ixodidae (HAkLOvá-KOKIKOvá et al. 2014), whereas, the presence of mites was infrequently reported, thus questioning the common occurrence of mite infestations among free-ranging reptiles in Central Europe. In contrast, captive reptiles can significantly be harassed by parasitic mites and occasionally by ticks (unpublished reports of veterinarians). Commonly, these parasites are objects of abhorrence and precipitant extermination, however, their significance as a part of the indigenous fauna or as regulators of host populations are hardly ever considered.

Ticks and mites are both small arachnids in the subclass Acarina. Ticks differ morphologically from other acarine taxa merely by the position of the spiracles and their larger body size. All ticks are blood-feeding, permanent ectoparasites of terrestrial vertebrates. They are referred to as herpetophagous if they feed on amphibians or reptiles without any recognizable damage to the parasite. Almost all such ticks are members of the family Ixodidae. In contrast, herpetophagous mites are distributed over at least five families. At the utmost, two developmental stages in a mite’s life cycle are parasitic; some mite species being blood-sucking ectoparasites, others skin-mining endoparasites, which attack terrestrial and aquatic hosts, e.g., newts. The majority are stenoxenous parasites, i.e., they commonly feed on one or very few host taxa only and, in urgent need of food, can attack a small number of further host species. On the contrary, an euryxenous parasite feeds on a broad range of host species even-handedly. Almost all Austrian hard ticks are three-host ticks, they detach regularly from their host for the moult after blood-sucking. In many species each developmental stage prefers a varying set of hosts, the herpetophagous blood-suckers being usually found among the juvenile Ixodidae developmental stages (SERVICE 1986; LUCIUS & LOOS-FRANK 1997; KOLONIN 2004).

Acarine species now indigenous to Central Europe must have established at least one replicating and self-sustaining population in that region, irrespective of their auto- or allochthonous origin. Prior requirement for the establishment of a founder population by an incoming parasite is the permanent availability of suitable hosts, whereas convenient habitats and most environmental factors are second-rank. Large numbers of exotic ticks and parasitic mites are displaced by imported host animals and returning migratory birds which carry adhered hard ticks over long distances. However, peregrine species cannot establish viable populations without the creation of suitable habitats by man. The artificial conditions in vivaria and outdoor pet facilities are substantially promoting the acclimatization of non-native parasites (NOWAK 2010). The popularity of keeping exotic herpetological taxa as pets has led to multiple opportunities for invasive acarine parasite species, and some have evidently perceived their chance (Table 1).

The latest revision of the Austrian tick fauna was done almost 30 years ago (RADDA et al. 1986), indigenous herpetophagous mites have never been emphasized. The following key was provided to facilitate the identification of Acarina associated with reptiles in Central Europe:

A - Mites and hard ticks, gross classification

1a Acarina with six legs, spiracles lacking 2
1b Acarina with eight legs 3
2a Length < 0.1 mm 3
2b Length > 0.6 mm hard tick larva
3a Length 0.8 mm; spiracles present; mouthparts forming a clearly distinguishable capitulum 4
3b Length 0.18 mm to 0.5 mm; mouthparts directed straight forward; with a truncate dorsal shield covering the podonotal region 6
4a Genital aperture undeveloped; no porose areas on capitulum; length < 2 mm hard tick nymph
d
4b Genital aperture developed; dorsal surface covered with a scutum; length > 1.5 mm 5

5a Scutum covers only a small portion of the back, its uncovered parts are softer and
textensible; capitulum with two porose areas female hard tick
d
5b Scutum covers the whole back; capitulum usually without porose areas
male hard tick

6a Genital aperture small, atrophied; dorsal shield covers less than half of the back Ophionyssus protonymph

6b Genital aperture vast; dorsal shield longer than half of the back, divided or entire, if entire with less than 16 pairs of setae Ophionyssus female
d
6c Genital aperture vast; dorsal shield entire, longer than half of the back, with more than 15 pairs of setae Ophionyssus male

B - Hard ticks; according to NOSEK & SIXL (1972), revised by the author

Larvae
1a Anal grooves embracing the anus anteriorly Ixodes ricinus
1b Anal grooves embracing the anus posteriorly 2
2a Eyes present; palpi long Hyalomma aegyptium
2b Eyes absent; palpi short, conical; second palpal articles collectively wider than basis capituli 3

3a Second palpal article wider than basis capituli Haemaphysalis concinna
3b Second palpal article not as wide as basis capituli, protruding laterally; basis capituli oblong, curved at both sides Haemaphysalis parva
3c Second palpal article not protruding laterally; basis capituli semicircular Haemaphysalis inermis (feeds on Lacerta agilis)

Nymphs
1a Anal grooves embracing the anus anteriorly; no eyes; capitulum and palpi long 2
1b Anal grooves embracing the anus posteriorly; festoons present 3
2a Coxae I, II with posterior margins covered with folds of cuticle; scutum without cervical grooves Ixodes trianguliceps
2b External spurs on coxae present; scutum nearly circular with cervical and lateral grooves; basis capituli subtriangular Ixodes ricinus
3a Eyes present; scutum ovalo-rhomboid in outline; hypostome and palpi long; basis capituli subtriangular Hyalomma aegyptium
3b Eyes absent; palpi short, conical; second articles of palpi collectively wider than the basis capituli; coxae with spurs 4
4a Second palpal article wider than basis capituli; basis capituli with sides rounded, no cornua Haemaphysalis concinna
4b Second palpal article not as wide as basis capituli; basis capituli oblong dorsally Haemaphysalis inermis
5a Palpi not salient laterally; basis capituli with cornua Haemaphysalis inermis (feeds on Lacerta viridis)
5b Basis capituli without cornua Haemaphysalis parva (feeds on Lacerta agilis)

Females (I. ricinus, H. inermis and H. aegyptium only)
1a Anal grooves embracing the anus anteriorly; eyes absent; festoons absent; capitulum and palpi long Ixodes ricinus (isolated reports)
1b Anal grooves embracing the anus posteriorly 2
2a Submarginal eyes and coalesced festoons present Hyalomma aegyptium
2b Eyes absent; 9-11 festoons present, unclear when engorged; palpi not salient laterally, not wider than basis capituli Haemaphysalis inermis

Males (H. inermis and H. aegyptium only)
1a Submarginal eyes and coalesced festoons present Hyalomma aegyptium
1b Eyes absent; 9-11 festoons present; palpi not salient laterally, collectively not wider than basis capituli Haemaphysalis inermis (found on Lacerta viridis)

C - Parasitic stages of European Ophionyssus mites; according to MORAZA et al. (2009)

Protonymphs
1a Pygidial shield with 3 pairs of setae, transversely subcircular, 63 µm x 75 µm; podonotal shield 204 µm x 192 µm Ophionyssus naticis
No tick or mite species is known to parasitize amphibians in Central Europe, not even accidentally. The reasons for this are the non-survival of anurophilic, tropical *Amblyomma* ticks under Central European climate conditions on one hand (Simmons & Burridge 2000), and the rarity of large terrestrial accumulations of adult amphibians, the hosts of chigger mites, on the other. Keeping and breeding of *Testudo* tortoises, however, are very common activities in Austria. Based on an earlier estimation (Hassl 2004), tortoises are living in more than 10,000 Austrian households. Usually small herds of them are kept in outdoor-facilities. In some suburban areas the abundance of *Testudo* spp. is higher than it is in the wild. By this, sufficiently large populations of suitable hosts became available to establish transalpine populations of the Mediterranean tick species *Hyalomma aegyptium* (Linnaeus, 1758). Considering the absence of tick control by traders and purchasers (Nowak 2010), long-standing allochthonous populations of this tick species seem to be in place. This tick species was detected in Middle Europe (Styria) for the first time more than forty years ago (Sixl 1971) and is diagnosed in local live stocks of tortoises during parasitological screenings now and again (unpublished data). It is a strictly stenoxenous species, feeding on *Testudo* only. This three-host tick acts as an endophilic species in Central Europe, remaining in the synanthropic resting caverns of the hosts. But it is unknown where exactly the moults take place and where and how the ticks infest the tortoises. Only adults of *Testudo graeca* Linnaeus, 1758 seem to fit entirely the tick’s requirements as a host. Possibly only unusually cavernophilous members or populations of this tortoise are ideal hosts (Caenisir et al. 2002; Široký et al. 2009). The seasonal activity of the host population is presumably responsible for the fluctuation in the tick’s abundance (Široký et al. 2009; Gemel & Hörweg 2011). Nevertheless the crucial needs for the survival of this tick are obviously met in some Central European anthropogenic turtle habitats.

*Ixodes ricinus* (Linnaeus, 1758) is long known as an extremely euryxenous tick. Larvae and nymphs attack terrestrial mammals, birds and reptiles likewise. This tick is a free-ranging and outdoor feeding acarine, inhabiting scrub forest edges in humid valley plains (Fig. 1). If *I. ricinus* attacks reptiles, it prefers animals with permanent ground contact of the belly. Lizards seem to be a common host of this tick species in certain regions, e.g., the Spessart.
Table 1: Ticks and mites parasitizing on free-ranging reptiles in Austria. +++ - frequently, ++ - regularly, + - rarely.

<table>
<thead>
<tr>
<th>Acarina species</th>
<th>Parasitic stages</th>
<th>Hosts</th>
<th>In Austria this species is</th>
<th>It attacks man</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ixodes ricinus</em></td>
<td>larva, nymph</td>
<td>Larva: <em>Lacerta agilis</em> LINNAEUS, 1758; <em>Lacerta viridis</em> (LAURENTI, 1768); <em>Zootoca vivipara</em> (LIGHTENSTEIN, 1823). Nymph: <em>Lacerta agilis</em>; <em>Lacerta viridis</em>; <em>Zootoca vivipara</em>, <em>Anguis fragilis</em> LINNAEUS, 1758; <em>Coronella austraica</em> LAURENTI, 1768; <em>Zamenis longissimus</em> (LAURENTI, 1768); <em>Natrix natrix</em> (LINNAEUS, 1758), probably a misidentified host</td>
<td>autochthonous</td>
<td>+++</td>
<td>PFOSER 1948; SIXL et al. 1971</td>
</tr>
<tr>
<td><em>Ixodes (Exopalpiger) trianguliceps</em> BIRULA, 1895</td>
<td>nymph</td>
<td><em>Zootoca vivipara</em>, maybe a rare case of herpetophagy</td>
<td>autochthonous</td>
<td>no</td>
<td>SIXL et al. 1969 1971</td>
</tr>
<tr>
<td><em>Haemaphysalis concinna</em> KOCH, 1844</td>
<td>nymph</td>
<td><em>Podarcis muralis</em> (LAURENTI, 1768); <em>Lacerta viridis</em>; <em>Zamenis longissimus</em></td>
<td>autochthonous</td>
<td>++</td>
<td>PFOSER 1948; SIXL et al. 1969</td>
</tr>
<tr>
<td><em>Hyalomma aegyptium</em> LINNAEUS, 1758</td>
<td>larva, nymph, adult</td>
<td>stenoxen: <em>Testudo graeca</em>, LINNAEUS, 1758; maybe also: <em>Testudo marginata</em> SCHÖPF, 1789; unlikely: <em>Testudo hermanni</em> GMELIN, 1789</td>
<td>introduced by pet trade, in synanthropic habitats, origin Mediterranean region</td>
<td>no</td>
<td>SIXL 1971</td>
</tr>
<tr>
<td><em>Ophionyssus natricis</em> (GERVAIS, 1844)</td>
<td>protonymph, adult</td>
<td>captive snakes, occasionally captive Agamidae, possibly free-ranging reptiles in synanthropic habitats</td>
<td>in synanthropic habitats only, maybe an invasive species, presently cosmopolitan, origin unknown</td>
<td>++</td>
<td>no citable reference, diagnostic reports of veterinarians</td>
</tr>
<tr>
<td><em>Ophionyssus lacertinus</em> (BERLESE, 1892)</td>
<td>protonymph, adult</td>
<td>Lacertidae: <em>Podarcis muralis</em>, <em>Lacerta viridis</em>; maybe in synanthropic or artificial habitats only</td>
<td>unknown; reports from Great Britain, Italy, the Netherlands</td>
<td>+</td>
<td>no reference</td>
</tr>
</tbody>
</table>
Mountains in Germany (JANSEN 2002), and may be infested by more than 100 ticks at a time (MALKMUS 1995). It is still unknown whether the reptilian blood suffices the nutrient needs of this tick for successful moulting or egg-production.

This widespread tick species is replaced in moist habitats by the marsh or vole tick, *Ixodes (Exopalpiger) trianguliceps* BIRULA, 1895. Similar to its lacertilian host, *Zootoca vivipara* (LICHTENSTEIN, 1823), this tick is more sensitive to aridity than other species of the genus and bound to habitats with high relative humidity. In Austria the tick and the lizard can live at high altitudes (Fig. 1), the tick up to 2,400 m a.s.l., in young forest plantations, clearings, moors, and extensively used and well structured meadows and pastures. The tick is considered a specialized blood-feeder on mice and shrews (SIXL et al. 1969), but its biology is largely unknown. The marsh tick has only once been found parasitizing a reptile (*Zootoca vivipara*), in Poland (NOWAK CHMURA & SIUDA 2012). So parasitism of this tick species on a reptile may be seen as an occasional event.

The bush tick, *Haemaphysalis concinna* C. L. KOCH, 1844, is the typical xerothermophilic tick of ruminant pastures. This species is autochthonous in, but probably restricted to the east of Austria (Fig. 1). It prefers warm, dry habitats, particularly sheep and cattle grazing grounds, but also thin forests with dense undergrowth. Usually it feeds on terrestrial mammals, but in case of starvation, lizards and even snakes are accepted by the nymphs (HASL 2003). Some other Central European *Haemaphysalis* species are well known to feed on reptiles, but they were not located in Austria.

The existence of herpetophagic mites in the untouched wild of Central Europe was never confirmed. In their natural alien habitats outside vivaria, their abundance is usually low (NOWAK 2010). Although there are at least ten genera of mites feeding on reptiles worldwide, the integration of a peregrine mite into a local biocenosis seems to be intricate. One species of herpetophagic mite, *Ophionyssus saurarum* (OUDEMANS, 1901), is considered to be autochthonous, feeding on Lacertidae only (BECK & PANTCHEV 2006). *Ophionyssus natricis* (Gervais, 1844) and *O. lacertinus* (BERLESE, 1892) are strongly associated with keeping reptiles in vivaria, optionally they live in synanthropic and artificial habitats outside
reptilian diseases are the infections of lizards or remove ticks from infested congeners in an act of concerted grooming. It occurs via tick ingestion. It is unknown whether the tortoises pick up non-attached lizards with ticks during nibbling inside their rest cavities or by relocating host populations or by reducing predator populations. These mite species might be invasive species in the stage of dissemination, or overlooked for a long time and misdiagnosed autochthonous animals. There is a singular report of *O. natricis* mites “existing in nature” in Egypt (Yunker 1956).

Some Central European ticks are very effective vectors of tick-borne pathogens to man (Sixl & Nosek 1972; Radda et al. 1986). But there is only one tick-borne etiologic agent associated with reptiles, the bacterium *Borrelia lusitaniae* Le Fleche et al., 1997, which is one of several local pathogens causing Lyme borreliosis in man. It is transstadially transmitted by *I. ricinus*, but not transovarially, which is why the tick cannot serve as reservoir for the bacterium. In Central Europe, the lacertids *Lacerta agilis* Linnaeus, 1758 and *Podarcis muralis* (Laurenti, 1768) are considered the most important reservoir hosts (Richter & Matuschka 2006). In habitats with rich syntopic populations of both *I. ricinus* and lizards, there is a high probability of *B. lusitaniae* spirochetes occurring. By entering such habitats the risk of acquiring a Lyme disease is considerable to man.

A well-known example of a tick-borne reptilian disease is the infection of *Testudo graeca* Linnaeus, 1758 and *Testudo marginata* Schoepff, 1782 with *Hemolivia mauritanica* (Sergent & Sergent, 1904). In the Maghreb and Middle East countries, this apicomplexan parasite was detected in the erythrocytes of these tortoises with prevalences of up to 92% (Siroky et al. 2009). Vector and definitive host of this parasite is *H. aegyptium* ticks only; the infection occurs via tick ingestion. It is unknown whether the tortoises pick up non-attached ticks during nibbling inside their rest cavem or remove ticks from infested congeners in an act of concerted grooming.

Less-known examples of mite-borne reptilian diseases are the infections of lizards with *Karyolysus latus* Svahn, 1975 and *K. lacazei* Labbé, 1894. Both species are indigenous, intracellular blood parasites, they are characterized by a transstadial and a transovarial transmission in gamasid mites (Gamasoidea). *Ophionyssus saurarum* mites are used as vector, reservoir and definitive host, the mites must be ingested to infect the lizards. It is believed that hard ticks can take the mite’s place, to explain the frequent presence of *Karyolysus* in spite of the low abundance of mites (Hassl 2003; Halkova-Kocikova et al. 2014). The consequences of such infections to the dynamics of lizard populations are unknown. Pantchev (2005) stated that *Ophionyssus natricis* transmits the nosocomial bacterium *Aeromonas hydrophila* (Chester, 1901), causing a haemorrhagic septicaemia in pet snakes and gastroenteritis in man, which is not commonly accepted.


KEY WORDS: Reptila: Squamata: Serpentes, Sauria; Arachnida: Mesostigmata: Ixodida, Macronyssidac: herpetophagic acarina; hard ticks; Ophionyssus mites; identification key of species, veterinary medicine, parasitology, Central Europe

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