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ORIGINAL ARTICLE

Morphological abnormalities in ticks (Acari: Ixodidae) feeding on humans in Central Black Sea region, Turkey

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Abstract During our parasitological studies on ticks infesting humans, we noticed 127 ticks with abnormal morphology. Some of these specimens had local abnormalities including the absence of one or two legs, one porose area, one spiracle, while others had also general abnormalities such as asymmetric body, gynandromorphism, gigantism or caudal constriction. Most encountered tick species with abnormalities observed were *Hyalomma marginatum* ($n = 113$, 88.97 %), followed by *Hyalomma excavatum* ($n = 3$, 2.36 %) and *Rhipicephalus turanicus* ($n = 3$, 2.36 %). Atrophy or lack of the one adanal plate ($n = 49$, 38.58 %) was the most encountered local abnormalities. Other local abnormalities were atrophy or lack of one leg ($n = 36$, 28.35 %) and atrophy or lack one spiracle ($n = 11$, 8.66 %). The most encountered general abnormalities were asymmetry ($n = 9$, 7.08 %), constriction ($n = 5$, 3.93 %) and gynandromorphism ($n = 4$, 3.15 %), respectively. In the present study, morphological abnormalities in ticks collected on humans were investigated in detail for the first time and many forms of morphological abnormalities were reported for Turkey.

Keywords Abnormalities · Teratology · Ticks · Turkey

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Introduction

Morphological abnormalities in ticks are extraordinary phenomena, and they occur at relatively low frequencies in nature (Nowak-Chmura 2012). Somatic or germinal mutations, environmental stress and host resistance to tick infestation are the main causes of morphological abnormalities in ticks (Latif et al. 1988; Dergousoff and Chilton 2007). In addition, abnormal ticks can be experimentally obtained by exposed chemical agents (e.g. apholate–acetone solutions) or high relative humidity (Oliver and Delfin 1967; Buczek 2000).

Gynandromorphism is one of the most documented abnormalities in ticks (Labruna et al. 2002; Keskin et al. 2012; Prusinski et al. 2015), but also there are several reports about other types of morphological abnormalities, such as asymmetry, fusion of adanal plates and festoons, atrophy or lack of one or two legs (Campana-Rouget 1959b, Guglielmone et al. 1999; Dergousoff and Chilton 2007; Kar et al. 2015).

According to classification of Campana-Rouget (1959a, b), general anomalies in ticks have been mainly described under the main title as changes in body shape, asymmetry, nanism, gynandromorphism and duplication while local abnormalities have been described as asymmetry of spiracle and scutum, fusion of adanal plates, malformation of capitulum, abnormalities of appendages and abnormalities of festoons. In addition, abnormalities of appendages were separated into two major categories by Campana-Rouget (1959a, b): (1) schizomely (bifurcation of the claws, tarsus and femur) and (2) meiomely which were further divided into three subcategories: (1) symely (fusion of appendages), (2) atrophy (appendages reduced in size) and (3) ectromely (the loss of one or more legs). Another terminology for describing local abnormalities in ticks was

suggested by Buczek (2000), e.g. oligomely = complete absence of appendages, heterosymely = the fusion of appendages lying on the same side of the idiosoma, symely = the fusion of appendages lying on the opposite side of the idiosoma, polymely = the formation of supernumerary appendages, atrophy = the reduction in the length of appendages, heteromorphose = the deformation of appendage segments and joints and ectomely = changes of place implantation of appendages into idiosoma.

Although, to date, many authors have documented abnormalities in several tick species (Feldman-Muhsam 1950; Latif et al. 1988; Estrada-Peña 2001; Labruna et al. 2002; Dergousoff and Chilton 2007), there is very limited documentation about morphological abnormalities in ticks of Turkey (Keskin et al. 2012; Kar et al. 2015). In the present study, morphological abnormalities in ticks collected on humans were investigated in detail for the first time and many forms of morphological abnormalities, including gynandromorphism, were reported for Turkey.

Materials and methods

In 2009, 6576 ticks were collected from humans in Tokat Province and its vicinity (Central Black Sea region, Turkey) by health personnel under aseptic conditions, stored in 70 % ethanol and deposited in the Acarology Laboratory, Department of Biology, Gaziosmanpasa University (Tokat, Turkey), for morphological identification. The external morphology of abnormal ticks was examined under the stereomicroscope (MZ16, Leica, Wetzlar, Germany) and photographed with a digital camera (EOS 550D, Canon, Japan). Ticks were identified species using the keys of Filippova (1997), Walker et al. (2000), Estrada-Peña et al. (2004) and Apanaskevich and Horak (2008). After the identification, ticks were deposited to the Turkish Tick Collection (Department of Biology, Gaziosmanpasa University, Tokat, Turkey) for the further studies of interested scientists.

In the present study, we followed proposals of Campana-Rouget (1959a, b) for the terms used to describe the general and local abnormalities in ticks.

Results

In total, 6576 ticks belonging to 20 tick taxa (1 species of Argasidae and 18 species and 1 subspecies of Ixodidae) were examined for morphological abnormalities. Of them, 127 (1.93 %) were determined to be having general and local morphological abnormalities (Table 1). Abnormalities were found in eight species, namely *Dermacentor marginatus*, *Haemaphysalis parva*, *Haemaphysalis punctata*, *Hyalomma aegyptium*, *Hyalomma excavatum*, *Hyalomma marginatum*, *Rhipicephalus bursa* and *Rhipicephalus turanicus*.

Most encountered tick species with abnormalities was *H. marginatum* ($n = 113$, 88.97 %), followed by *H. excavatum* ($n = 3$, 2.36 %) and *R. turanicus* ($n = 3$, 2.36 %). Atrophy or lack of the one adanal plate ($n = 49$, 38.58 %) was the most encountered local abnormalities, followed by atrophy or lack of one leg ($n = 36$, 28.35 %) and atrophy or lack one spiracle ($n = 11$, 8.66 %). The most frequently encountered general abnormalities were asymmetry ($n = 9$, 7.08 %), constriction ($n = 5$, 3.93 %) and gynandromorphism ($n = 4$, 3.15 %), respectively. Some abnormal specimens detected in this study are shown in Figs. 1, 2.

No abnormalities were found in *Argas vespertilionis*, *Dermacentor niveus*, *Haemaphysalis erinacei taurica*, *Haemaphysalis sulcata*, *Hyalomma rufipes*, *Ixodes frontalis*, *Ixodes gibbosus*, *Ixodes laguri*, *Ixodes redikorzevi*, *Ixodes ricinus*, *Rhipicephalus annulatus* and *Rhipicephalus sanguineus*.

Discussions

Morphological abnormalities are very rare phenomena in nature (Campana-Rouget 1959a, b; Keskin et al. 2012), and various biological or non-biological factors (somatic or germinal mutations, exposure to chemical agents, environmental stress and host resistance to tick infestation) are considered as possible causes of abnormalities in ticks (Campana-Rouget 1959a, b; Guglielmone et al. 1999; Dergousoff and Chilton 2007).

Neumann (1899) was the first scientist who documented some abnormalities in ticks. Campana-Rouget (1959a, b) and Tovornik (1987) prepared a comprehensive list of general and local tick abnormalities while Guglielmone et al. (1999), Dergousoff and Chilton (2007), Nowak-Chmura (2012), Keskin et al. (2012) and Kar et al. (2015) documented several types of general and local abnormalities such as asymmetry, bifurcation, gynandromorphism, ectromely and atrophy. Senevet (1922) determined 0.7 % abnormality in some species of the genus *Hyalomma*, whereas Černý (1957) recorded 1.3 % abnormal specimens amongst 15,000 ticks belonging to genera *Ixodes*, *Dermacentor* and *Haemaphysalis*. Tovornik (1987) investigated 53,930 ticks for the presence of morphological abnormality and she documented that abnormality rate was 0.028 % ($n = 15$) in five tick species: *Ixodes trianguliceps*, *Ixodes hexagonus*, *I. ricinus*, *H. punctata* and *H. sulcata*. Guglielmone et al. (1999) reported 62 (0.1 %) ticks with phenotypic abnormality from 64,473 specimens collected from March 1976 to March 1997 in mainland Argentina.

Table 1 General and local abnormalities in ticks found in this study

Type of abnormalities	Tick species	*n*	%[a]	%[b]
General				
Gynandromorphism	*Hyalomma marginatum* (4)	4	3.15	0.061
Asymmetries	*Hyalomma excavatum* (1♂), *Hyalomma marginatum* (5♂, 1♀), *Rhipicephalus bursa* (1♂, 1♀)	9	7.087	0.137
Idiosomal constriction	*Hyalomma marginatum* (5♂)	5	3.937	0.076
Elongations	*Hyalomma marginatum* (3♂)	3	2.362	0.046
Gigantism	*Hyalomma marginatum* (1♂)	1	0.787	0.015
Local				
Fusion of adanal plates	*Hyalomma marginatum* (2♂)	2	1.575	0.03
Fusion of festoons	*Hyalomma marginatum* (1♂)	1	0.787	0.015
Lack/atrophy of one leg	*Dermacentor marginatus* (1♀), *Haemaphysalis punctata* (1♀), *Hyalomma aegyptium* (1♂), *Hyalomma marginatum* (21♂, 11♀), *Rhipicephalus turanicus* (1♂)	36	28.35	0.547
Lack of two legs	*Hyalomma marginatum* (1♀)	1	0.787	0.015
Lack of one porose area	*Haemaphysalis parva* (1♀), *Hyalomma marginatum* (1♀)	2	1.575	0.03
Lack/atrophy of one spiracle	*Hyalomma aegyptium* (1♂), *Hyalomma excavatum* (1♂), *Hyalomma marginatum* (8♂, 1♀)	11	8.661	0.167
Lack/atrophy of one adanal plate	*Hyalomma excavatum* (1♂), *Hyalomma marginatum* (46♂), *Rhipicephalus turanicus* (2♂)	49	38.58	0.745
Lack of Haller's organ	*Hyalomma marginatum* (1♂)	1	0.787	0.015
One spur on tarsi	*Hyalomma marginatum* (1♂)	1	0.787	0.015
Protuberance in legs	*Rhipicephalus bursa* (1♂)	1	0.787	0.015

[a] Rate of total abnormal ticks $n = 127$

[b] Rate of total examined material

Morphological abnormalities in ticks of Turkey have been documented for the first time by Yalvac and Ozkan (1980) in a poster presentation. Other than this study, one case of gynandromorphism in *H. marginatum* has been reported by Keskin et al. (2012). Recently, 33 specimens belonging to five tick species were found to have external morphological anomalies by Kar et al. (2015), including one case of gynandromorphism in *H. marginatum.*

In total, 127 (1.94 %) were determined to have morphological abnormalities in this study. General abnormalities were found in only 23 (0.35 %) specimens, represented by *H. marginatum* ($n = 19$), *H. excavatum* ($n = 1$) and *R. bursa* ($n = 2$). On the other hand, local abnormalities were found in 105 (1.59 %) specimens, represented by *D. marginatus* ($n = 1$), *H. parva* ($n = 1$), *H. punctata* ($n = 1$), *H. aegyptium* ($n = 2$), *H. excavatum* ($n = 2$), *H. marginatum* ($n = 94$), *R. bursa* ($n = 1$) and *R. turanicus* ($n = 3$). Herein, morphological abnormalities in Turkish populations of *D. marginatus*, *H. aegyptium* and *H. excavatum* were also documented for the first time in this study.

Gynandromorphism is an extraordinarily rare event in which both female and male phenotypic characteristics are simultaneously displayed in an organism (Campana-Rouget 1959a; Guglielmone et al. 1999; Keskin et al. 2012). This rare phenomenon was found at a general rate of 1 gynandromorph per 13,900 adult ticks (Guglielmone et al. 1999). However, the frequency of gynandromorphism is relatively higher in the natural populations of *Amblyomma* and *Hyalomma* ticks, compared to other genera (Pervomaisky 1950; Guglielmone et al. 1999). To date, approximately 80 natural cases of gynandromorphic ticks have been documented in Ixodidae (Labruna et al. 2002; Keskin et al. 2012; Kar et al. 2015; Prusinski et al. 2015). In this study, gynandromorphism was observed in four specimens of *H. marginatum*. Of them, three were bipartite protogynander (where the external characters of male and female ticks are equally represented), while one gynander was deuterogynander (where 1 sex is reduced to a quadrant). Asymmetries were the most encountered general abnormalities, where nine cases (*H. excavatum*: one, *H. marginatum*: six, *R. bursa*: two) have been reported. Idiosomal constriction, elongations, gigantism and bifurcation of the idiosoma were the other types of general abnormalities observed relatively frequently.

Ten different local abnormalities have been observed in eight tick species (Table 1). Within the examined material, lack or atrophy of one adanal plate was the most observed

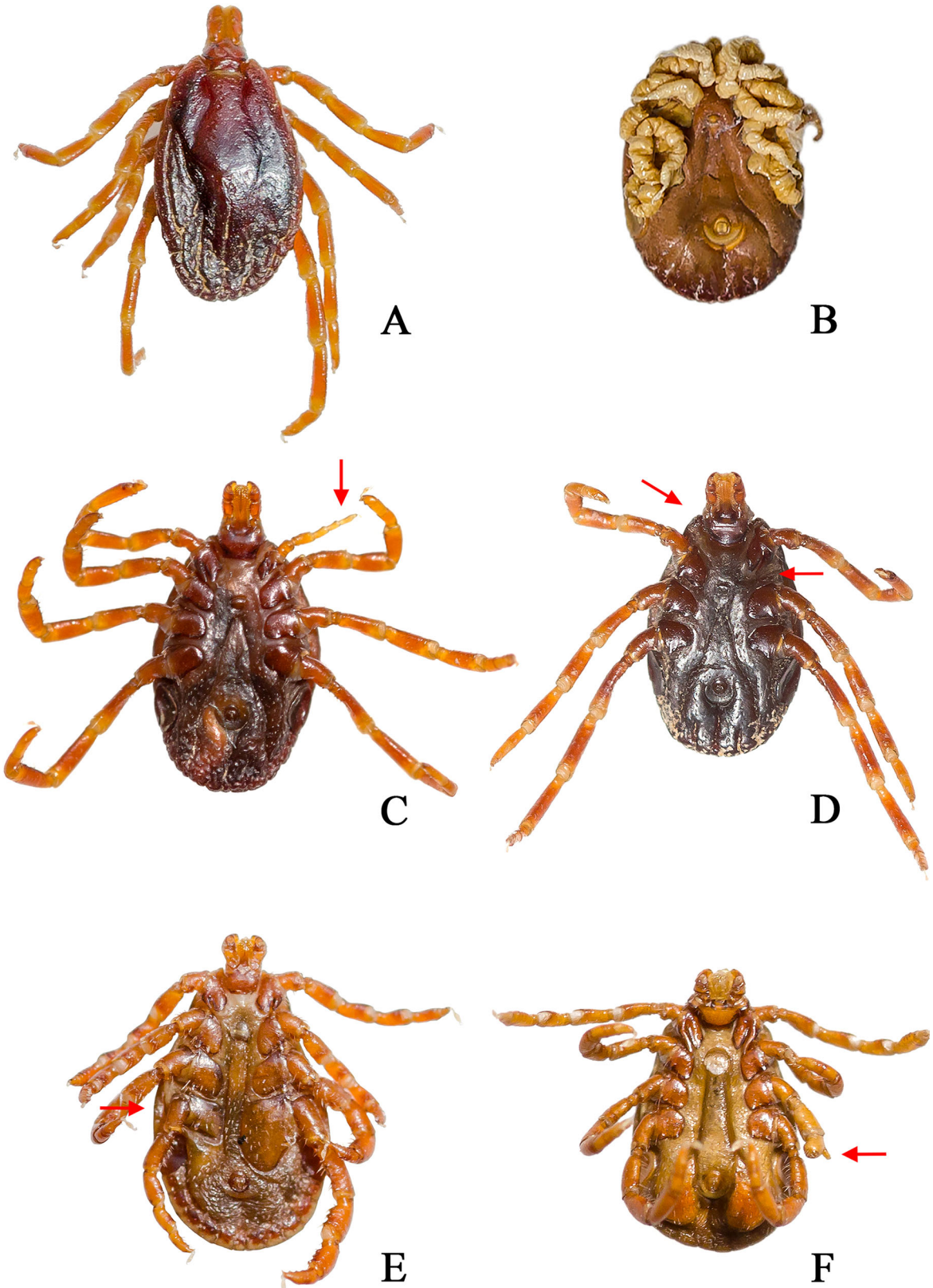

Fig. 1 Abnormalities in ticks collected humans. **a** gynandromorphism in *H. marginatum*, **b** deformation of legs in *D. marginatus*, **c** atrophy of first left leg in *H. marginatum*, **d** ectromely of first right and second left legs in *H. marginatum*, **e** atrophy of fourth right leg and its associated coxa in *D. marginatus*, **f** protuberance in third left legs in *R. bursa*

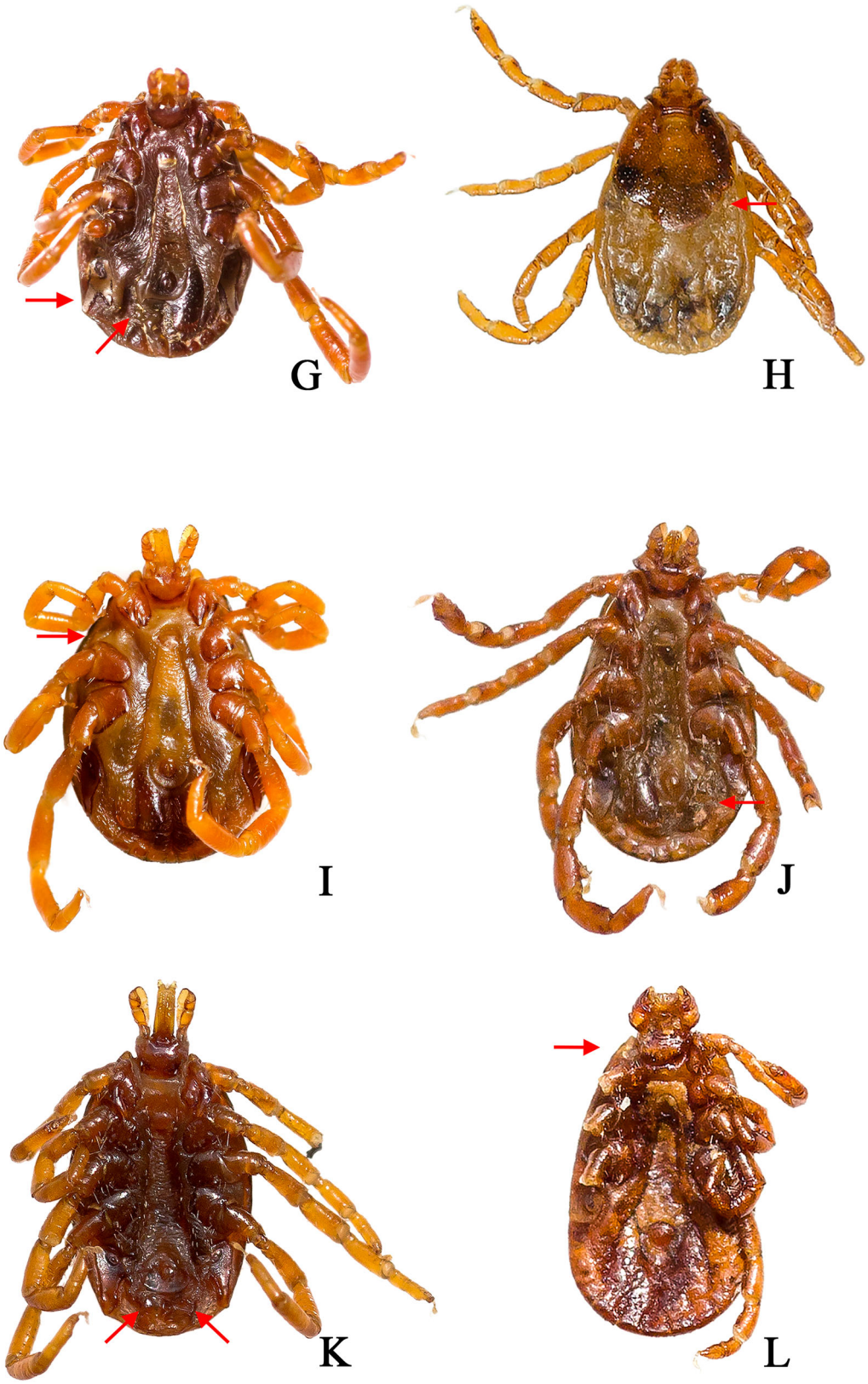

Fig. 2 Abnormalities in ticks collected humans. **g** bifurcation of right spiracular plate and lack of right adanal and subanal plates in *H. marginatum*, **h** scutal anomaly in *R. bursa*, **i** ectromely of second right leg in *H. marginatum*, **j** lack of left adanal and accessory plates in *R. turanicus*, **k** lack of both adanal, subanal and accessory plates in *H. marginatum*, **l** ectromely of first right leg in *H. punctata*

local abnormalities with 46 cases. Second most encountered local abnormalities were lack or atrophy of one leg with 36 cases. Similar cases have been reported in several tick species including *Amblyomma flavomaculatum*, *Dermacentor andersoni* and *H. aegyptium* (Dergousoff and Chilton 2007; Nowak-Chmura 2012). In addition, atrophy or lack of one spiracle was reported in 11 specimens. Campana-Rouget (1959b) documented several types of spiracular abnormalities (asymmetry) in *Amblyomma hebraeum* and *Amblyomma longirostre*. In addition, Kar et al. (2015) reported spiracular abnormalities in *Hyalomma scupense*, *H. marginatum* and *R. turanicus*. Spiracular abnormalities in *H. aegyptium* and *H. excavatum* were documented for the first time in Turkey.

In conclusion, morphological abnormalities in ticks collected on humans were investigated in detail for the first time in Turkey. In addition, many types of morphological abnormalities, including gynandromorphism, were reported with this study.

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