A new record and descriptions of males of two Stigmaeus species from Turkey (Acari: Stigmaeidae)
I. Ulucay

To cite this version:
I. Ulucay. A new record and descriptions of males of two Stigmaeus species from Turkey (Acari: Stigmaeidae). Acarologia, Acarologia, 2015, 55 (3), pp.255-266. <10.1051/acarologia/20152165>. <hal-01548471>

HAL Id: hal-01548471
https://hal.archives-ouvertes.fr/hal-01548471
Submitted on 27 Jun 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License
Acarologia is proudly non-profit, with no page charges and free open access

Please help us maintain this system by encouraging your institutes to subscribe to the print version of the journal and by sending us your high quality research on the Acari.

Subscriptions: Year 2017 (Volume 57): 380 €
http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php

Previous volumes (2010-2015): 250 € / year (4 issues)
Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)

Acarologia is under free license and distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.
A new record and descriptions of males of two *Stigmaeus* species from Turkey (Acari: Stigmaeidae)

İsmail Uluçay

(Received 11 March 2015; accepted 11 May 2015; published online 30 September 2015)

Hakkari University Colemerik Vocational School 30000, Hakkari, Turkey. iulucay@gmail.com

**ABSTRACT** — *Stigmaeus pulchellus* Kuznetzov, 1978, reported for the first time from Turkey, is described and illustrated based on females. In addition to the male and nymphal stages of this species, the male of *Stigmaeus kumalariensis* Akyol and Koç, 2007 is also described and illustrated in this article for the first time. The males and females presented differences in chaetotaxy, notably the absence of seta $h_3$ in the male of *S. pulchellus*.

**KEYWORDS** — Prostigmata; Raphignathoidea; *Stigmaeus pulchellus*; *Stigmaeus kumalariensis*; Turkey

**INTRODUCTION**

Stigmaeidae is a family within the superfamily Raphignathoidea. These mites live in or on soil, grass, leaf, mulch, lichen, bark, beetle frass, crevices in rock and leaf cavities, and a few of them are parasitic on phlebotomine flies (Meyer 1969; Ueckermann and Meyer 1987; Doğan and Ayyıldız 2003a, b; Akyol and Koç 2007, 2010; Noei et al. 2007; Dönel and Doğan 2011; Uluçay and Koç 2014). Currently this family consists of more than 500 species in 32 valid genera (Doğan et al. 2011; Bagheri et al. 2012; Nazari et al. 2012). Up to now *Agistemus* Summers, *Cheylostigmaeus* Willmann, *Eustigmaeus* Berlese, *Ledermuelleriopsis* Willmann, *Mediolata* Canestrini, *Stigmaeus* Koch, *Prostigmaeus* Kuznetsov, *Storchia* Oudemans, *Villersia* Oudemans, *Zetzellia* Oudemans and *Eryngiopus* Summers have been reported from Turkey (Doğan 2007; Akyol and Koç 2007; Dönel and Doğan 2011; Özçelik and Doğan 2011; Doğan et al. 2015; Uluçay 2015). In this article, the male, deutonymph and protonymph of *Stigmaeus pulchellus* Kuznetzov, 1978 and the male of *S. kumalariensis* are described and illustrated for the first time. *Stigmaeus pulchellus* Kuznetzov, 1978 reported for the first time from Turkey.

**MATERIALS AND METHODS**

The soil and litter samples taken from various habitats in Hakkari Province in 2014 and Hatay Province in 2014 were brought to the laboratory in nylon bags, and extracted by Berlese funnels for five to seven days. Mites were collected in 70% ethanol. Stigmaeid mites were picked from the samples under a stereomicroscope and mounted on slides in Hoyer’s medium. The mite figures were drawn and measured by means of a Leica DM 4000 B re-
search microscope with special software (Leica Application Suite Version 3.6.0 - Build:488) for measurements. The setal nomenclature follows that of Kethley (1990). The specimens are slide mounted and deposited in the Acari Collection of Hakkari University, Hakkari, Turkey. All measurements are given in micrometers (µm). Measurements of legs have been taken from base of femur to tip of tarsal claw.

RESULTS

Family: Stigmaeidae Oudemans, 1931
Type genus: Stigmaeus Koch, 1836
Type species: Stigmaeus cruentus Koch, 1836.

Stigmaeus pulchellus Kuznetzov, 1978

Female (n = 13) (Figures 1-2): Idiosoma oval, length of body (including gnathosoma) 505 – 552; width of body 269 – 311. Gnathosoma (Figure 2e). Length of gnathosoma 60 – 67; subcapitulum with two pairs of subcapitular setae (m and n), m 23 – 30, n 21 – 29 and two pairs of adoral setae, or1 and or2; distances m–m 29 – 38, n–n 23 – 26; palpi five segmented, palp tarsus with five simple setae + one tridentale eupathidium + one solenidion; palp tibia with two setae + one seta-like accessory claw + one well-developed claw; palp genu with one seta; palp femora with three setae; palp trochanter without seta.

Dorsum (Figure 1a) — Body elongated. Dorsum with 14 pairs of setae (setae h3 present); all dorsal shields reticulated; propodosomal shield with tree pairs of setae (vi, ve and sci); setae sce located on small auxiliary shields; eyes and postocular bodies absent; central shield elongate and with 2 pairs of setae (c1 and d1); humeral shields with seta c2; marginal shields elongate and with setae d2; median zonal shield divided and with seta e1; lateral zonal
shields wide and with setae $e_2$; intercalary shields with $f_1$; suranal shield entire, recessed posteriorly and with 3 pairs of setae ($h_1$, $h_2$ and $h_3$); dorsal body setae faintly spinulate; $c_2$ is the longest dorsal seta. Length of setae as follows: $vi$ 26 – 29, $ve$ 37 – 48, $sci$ 29 – 33, $sce$ 36 – 44, $c_1$ 29 – 34, $d_1$ 26 – 35, $d_2$ 29 – 35, $e_1$ 29 – 36, $e_2$ 26 – 37, $f_1$ 32 – 38, $h_1$ 36 – 44, $h_2$ 35 – 45, $h_3$ 24 – 26; distances between dorsal setae: $vi$-$vi$ 28 – 36, $ve$-$ve$ 45 – 60, $ve$-$sci$ 49 – 53, $sci$-$sce$ 29 – 36, $c_1$-$c_1$ 51 – 66, $c_1$-$d_1$ 61 – 76, $d_1$-$d_1$ 40 – 46, $d_1$-$d_2$ 68 – 87, $d_1$-$e_1$ 73 – 80, $e_1$-$e_1$ 49 – 62, $e_1$-$e_2$ 50 – 61, $e_1$-$f_1$ 38 – 47, $f_1$-$f_2$ 52 – 76, $h_1$-$h_3$ 31 – 40, $h_1$-$h_2$ 15 – 17, $h_2$-$h_3$ 10 – 13, $h_3$-$h_3$ 68 – 94, $h_3$-$h_3$ 93 – 101; ratios $vi$/$vi$ 0.8 – 1, $c_1$/$c_1$ 0.5 – 0.6, $d_1$/$d_1$ 0.6 – 0.8, $e_1$/$e_1$ 0.5 – 0.7, $f_1$/$f_2$ 0.5 – 0.6.

Venter (Figure 1b) — Endopodal shields separated, with subcutaneous reticulation and with ventral setae $1a$ 20 – 23, $3a$ 20 – 24, $4a$ 21 – 25; aggenital shields with subcutaneous reticulation and bearing four pairs of aggenital setae ($ag_2$-$ag_3$), length of $ag_1$ 17 – 20, $ag_2$ 18 – 20, $ag_3$ 19 – 21, $ag_4$ 21 – 29; anogenital area with two pairs of genital setae and three pairs of pseudanal setae ($ps_1$-$ps_3$); length of anogenital setae; $g_1$ 18 – 22, $g_2$ 25 – 31, $ps_1$ 40 – 53, $ps_2$ 50 – 54, $ps_3$ 21 – 25.

Legs (Figures 2a-d) — Length of legs I-IV: Leg I 157 – 186; leg II 125 – 151; leg III 129 – 151; leg IV 149 – 173; counts of setae (solenidia and setae $\kappa$ included) of legs I-IV: coxae 2, 2, 2, 2; trochanters 1, 1, 2, 1; femora 4, 4, 3, 2; genua 6($\kappa$), 5, 2, 2; tibiae 7($\varphi$,$\varphi_p$), 6($\varphi$), 6($\varphi$); tarsi 14($\omega$), 10($\omega$), 8($\omega$).

Male (n = 9) (Figure 3): Length of body (including gnathosoma) 343 – 391; width of body 159 – 192. Gnathosoma (Figure 3g). Length of gnathosoma 52 – 57; subcapitulum with two pairs of subcapitular setae ($m$ and $n$), $m$ 19 – 24, $n$ 17 – 22 and two pairs of adoral setae, $o_1$ and $o_2$; distances $m$-$m$ 25 – 31, $n$-$n$ 17 – 20; $m$-$m$ 0.9 – 1; palpal chaetotaxy as in female.

Dorsum (Figure 3a) — All dorsal shields reticulated; propodosomal shield with tree pairs of setae ($vi$, $ve$ and $sci$); setae $sce$ located on small auxil-
Lary shields; eyes and postocular bodies absent; central shield elongate and with 2 pairs of setae (c1 and d1); humeral shields with setae c2; marginal shields elongate and with setae d2; median zonal shield divided and with setae f1; lateral zonal shields wide and with setae e2; intercalary shields with f1; suranal shield entire and with two pairs of setae (h1 and h2); dorsal body setae faintly spinulate; c2 is the longest dorsal setae. Dimensions of setae as follows: vi 20 – 22, ve 29 – 32, sci 21 – 23, sce 26 – 29, c1 20 – 24, c2 36 – 42, d1 20 – 24, d2 21 – 27, e1 21 – 23, e2 21 – 24, f1 22 – 26, h1 23 – 28, h2 30 – 32; distances between dorsal setae: vi-vi 20 – 26, ve-ve 41 – 48, vi-ve 23 – 26, ve-sci 39 – 43, sci-sce 18 – 22, c1-c1 40 – 49, c1-d1 58 – 52, d1-d1 32 – 37, d1-d2 40 – 47, d1-e1 49 – 52, e1-e1 27 – 39, e1-f1 22 – 30, e1-f1 26 – 31, f1-f1 46 – 59, h1-h1 24 – 29, h1-h2 10 – 13, h2-h2 50 – 54; ratios vi/vi-vi 0.8 – 1.0, c1/c1-c1 0.5, d1/d1-d1 0.6 – 0.7, e1/e1-e1 0.6 – 0.8, f1/f1-f1 0.4 – 0.5.

Venter (Figure 3b) — Ventral view similar to that of the female. Lengths of setae: 1a 18 – 20, 3a 16 – 19, and 4a 16 – 18 and ratio 1a:3a:4a 1:2.1:1.2:1. Aggenital area with three pairs of setae, ag3 16 – 19, ag2 19 – 21 and ag3 18 – 22; anogenital area with three pairs of pseudanal setae ps1, 6, ps2 9 – 10 and ps3 17 – 19.

Legs (Figures 3c-f) — Length of legs: leg I 135 – 150, leg II 110 – 120, leg III 106 – 120, leg IV 125 – 139. Setal formulae of leg segments as follows: coxae 2, 2, 2, 2; trochanters 1, 1, 2, 0; femora 4, 4, 3, 2; genua 5(κ), 3, 0, 0; tibiae 7(φ, ϕ), 6(φ, ϕ), 6(φ, ϕ); tarsi 14(ω), 10(ω), 8(ω), 8(ω).

Protonymph (n = 7) (Figure 5) — Length of body (including gnathosoma) 311 – 399, width 161 – 238. Gnathosoma (Figure 5g). Length of gnathosoma 50 – 53; subcapitulum with one pair of subcapitular setae n 16 – 17 and two pairs of adoral setae, or1 and or2; distances n-n 20 – 25; palpal chaetotaxy as in female.

Dorsum (Figure 5a) — Dorsal view similar to that of the female except suranal shield without setae h3; length of dorsal setae: vi 17 – 19, ve 31 – 35, sci 20 – 23, sce 28 – 31, c1 22 – 25, c2 39 – 45, d1 23 – 25, d2 23 – 26, e1 24 – 27, e2 26 – 29, f1 28 – 32, h1 24 – 32, h2 25 – 34; distances between dorsal setae: vi-vi 25 – 31, ve-ve 44 – 54, vi-ve 22 – 24, ve-sci 34 – 45, sci-sci 74 – 85, sci-sce 17 – 26, c1-c1 44 – 48, c1-d1 48 – 54, d1-d1 25 – 32, d1-d2 41 – 64, d1-e1 41 – 51, e1-e2 28 – 40, e1-e2 23 – 36, e1-f1 24 – 35, f1-f1 42 – 51, h1-h1 21 – 29, h1-h2 9 – 15, h2-h2 40 – 52; ratios vi/vi-ve 0.6 – 0.7, c1/c1-c1 0.5 – 0.6, d1/d1-d1 1.0 – 1.2, e1/e1-e1 0.7 – 1.0, f1/f1-f1 0.6 – 0.7.

Venter (Figure 5b) — Ventral view similar to that of the female. Lengths of setae: 1a 15 – 17, 3a 15 – 16; without setae 4a; aggenital shields with subcutaneous reticulation and bearing one pair of aggenital setae ag1 11 – 14; anogenital area with three pairs of

Figure 4: *Stigmaeus pulchellus* Kuznetzov, 1978 (deutonymph): a – dorsal view, b – ventral view, c – leg I, d – leg II, e – leg III, f – leg IV, g – palp.
pseudanal setae \((pf_{1} - ps_{3})\); length of anogenital setae; \(ps_{1} 17 – 22, ps_{2} 13 – 19, ps_{3} 14 – 17\).

Legs (Figures 5c-f) — Length of legs I-IV : Leg I 121 – 130; leg II 97 – 104; leg III 95 – 101; leg IV 98 – 105; counts of setae (solenidia and setae \(\kappa\) included) of legs I-IV: coxae 2, 2, 2, 0; trochanters 0, 0, 1, 0; femora 4, 4, 3, 1; genua 5(\(\kappa\)), 3, 0, 0; tibiae 7(\(\phi\),\(\omega\)), 6(\(\phi\),\(\omega\)), 6(\(\phi\),\(\omega\)); tarsi 14(\(\omega\)), 10(\(\omega\)), 8(\(\omega\)), 7(\(\omega\)).

Material examined: 13 females, 9 males, 6 deutonymph and 7 protonymph from litter and soil under Astragalus sp., Turkey, Hakkari, Berçelan Mountain (37°43′07″N, 43°44′264″E, 3075 m), 25 June 2014.

The Turkish specimens resembles the type specimens and Iran specimens in most respects but differ in the length of body (including gnathosoma) 505 – 552. It is seen that the Turkish specimens are bigger: the length of body is 350 – 388 in the type specimen. The length of dorsal setae is similar to that of type specimen and longer than those of Iranian specimen. Apart from these, the other measurements and the features of our specimens resemble those of the type specimen in all respects (Kuznetsov 1978; Zarei and Bagheri 2012). Males of this species exhibit the same features of the female descriptions, except that the male tarsi I-IV are with two solenidia instead of one solenidion in female; the length of body and dorsal setae are shorter than those of the female; no setae \(h_{3}\) on the suranal shield; trochanteral chaetotaxy of the male 1, 1, 2, 0 and that of the female 1, 1, 2, 1; genual chaetotaxy of the male 5(\(\kappa\)), 3, 0, 0 and that of the female 6(\(\kappa\)), 5, 2, 2; the female bears 4 aggenital setae and the male bears 3 aggenital setae.

**Stigmaeus kumalariensis** Akyol & Koç 2007

Male \((n = 5)\) (Figure 6): Length of body (including gnathosoma) 246 – 279; width of body 117 – 163. Gnathosoma (Figure 6g). Length of gnathosoma 46 – 48; subcapitulum with two pairs of subcapitular setae \((m\) and \(n)\), \(m\) 15 – 16, \(n\) 9 – 11 and two pairs of dorsal setae, \(or_{1}\) and \(or_{2}\); palpi five segmented, palp tarsus with five simple setae + one tridentale eupathidium + one solenidion; palp tibia with two setae + one accessory claw + one well-developed claw; palp genu with two setae; palp femora with three setae; palp trochanter without setae.

Dorsum (Figure 6a) — Dorsal shields with thick reticulum. Propodosomal shield with three pairs of setae, one pair of eyes located between setae \(ve\) and \(sc\). Setae \(sc - sce\) located on small auxiliary shields. Central shield with two pairs of setae, \(e_{1}\), \(d_{1}\); setae \(c_{2}\) on humeral shield ventrolaterally; marginal shield with setae \(d_{2}\); median zonal shield divided and with setae \(e_{2}\); lateral zonal shields with setae \(e_{2}\); intercalary shield entire, with setae \(f_{1}\); suranal shield entire, with two pairs of setae, \(h_{1}\) and \(h_{2}\). Dorsal body setae sword shaped with a few faint serrations and all hysterosomal setae terminally expanded and serrated (Figures 6h-i). Dimensions of setae as follows: \(vi\) 26 – 32, \(ve\) 36 – 47, \(sc\) 16 – 19, \(sce\) 32 – 36, \(c_{1}\) 29 – 33, \(c_{2}\) 30 – 36, \(d_{1}\) 28 – 34, \(d_{2}\) 31 – 35, \(e_{1}\) 31 – 34, \(e_{2}\) 33 – 38, \(f_{1}\) 37 – 44, \(h_{1}\) 17 – 23, \(h_{2}\) 39 – 47; distances between dorsal setae: \(vi\) 15 – 17, \(ve\) 30 – 41, \(vi\) – \(ve\) 22 – 25, \(ve\) – \(sc\) 19 – 24, \(sc\) – \(sce\) 10 – 12, \(sci\) 65 – 76, \(sc\) – \(sce\) 75 – 99, \(sce\) – \(c_{1}\) 25 – 31, \(c_{1}\) – \(c_{1}\) 42 – 50, \(c_{1}\) – \(d_{1}\) 35 – 40, \(c_{2}\) – \(c_{2}\) 129 – 157, \(d_{1}\) – \(d_{1}\) 39 – 48, \(d_{1}\) – \(d_{2}\) 36 – 42, \(d_{1}\) – \(e_{1}\) 22 – 30, \(e_{1}\) – \(e_{1}\) 31 – 35, \(e_{1}\) – \(e_{2}\) 22 – 27, \(e_{1}\) – \(f_{1}\) 19 – 24, \(f_{1}\) – \(f_{1}\) 50 – 59, \(f_{1}\) – \(h_{1}\) 21 – 26, \(h_{1}\) – \(h_{1}\) 20 – 25, \(h_{1}\) – \(h_{2}\) 8 – 10, \(h_{2}\) – \(h_{2}\) 40 – 48; ratios \(vi\) – \(vi\) 1.6 – 1.9, \(c_{1}\) – \(c_{1}\) 0.6 – 0.7, \(d_{1}\) – \(d_{1}\) 0.7 – 0.8, \(e_{1}\) – \(e_{1}\) 0.9 – 1.0, \(f_{1}\) – \(f_{1}\) 0.7 – 0.8.

Venter (Figure 6b) — Ventral cuticle transversely striate between coxisternal regions II-III; coxisternal shields I-II and III-IV are surrounded by longitudinal striae. Lengths of setae: \(la\) 13 – 15, \(3a\) 14, and \(4a\) 12 – 13 and ratio \(la:3a:4a\) 1.2:1.2:1.1. Aggenital area with three pairs of setae, \(ag_{1}\) 11 – 14, \(ag_{2}\) 12 – 15 and \(ag_{3}\) 18 – 24; anogenital valves with three pairs of pseudanal setae, \(ps_{1}\), \(ps_{2}\) 7 – 9 and \(ps_{3}\) 14 – 17.

Legs (Figures 6c-f) — Length of legs: leg I 109 – 116, leg II 90 – 99, leg III 87 – 97, leg IV 98 – 109. Setal formulae of leg segments as follows: coxae 2, 2, 2, 2; trochanters 1, 1, 2, 1; femora 6, 5, 3, 2; genua 3(\(\kappa\)), 3(\(\kappa\)), 0, 0, tibiae 7(\(\phi\),\(\omega\)), 6(\(\phi\),\(\omega\)), 6(\(\phi\),\(\omega\)); tarsi 15 (2\(\omega\)), 11 (2\(\omega\)), 9 (2\(\omega\)), 9 (2\(\omega\)).

Material examined: 5 males from litter and soil under Pinus sp., Turkey, Hatay, Payas Village (36°45′32″N, 36°11′51″E, 4 m), 22 May 2014.

This species was described by Akyol and Koç (2007) from litter under Astragalus sp., Crateagus sp.,
Quercus sp. Verbascum sp. and Populus sp. in Afyonkarahisar and based on a female (Akyol and Koç 2007). Male specimens were described from litter and soil under Pinus sp. Males of this species exhibit the same features of the female descriptions, except that the male tarsi I-IV are with two solenidia instead of one solenidion in female; length of body and dorsal setae shorter than those of the female and intercalary shield fused (separate in the female).

**DISCUSSION**


The female of *S. luteus* bears 3 setae on the suranal shield, and the male has merely 2 (Summers, 1962, p 516). *S. arboricola* female bears $h_3$, whereas the male does not; trochanteral and gen-ual chaetotaxy are the same in the female and the male; the female has 4 aggenital setae and the male has 3 aggenital setae (Fan and Zhang 2005, p 92).

In *S. brevisetis* the female has $h_3$ but the male and proponenty do not; trochanteral chaetotaxy of the male 1, 1, 2, 0 and that of the female 1, 1, 2, 1; genital chaetotaxy of the male 5($\kappa$), 2, 0 and that of the female 6($\kappa$), 5, 2, 2; the female bears 4 aggenial setae and the male bears 2 aggenital setae (Wood 1973, p 370; Fan and Zhang 2005, p 93).

The male of *S. candicus* has been additionally described: the length of seta $h_3$ on the female is given, but that of the male isn’t stated; trochanteral chaeto-taxy of the male 1, 1, 2, 0 and that of the female 1, 1, 2, 1; genital chaetotaxy of the male 6, 2, 0 and that of the female 6, 2, 0, 1. (Fan and Li, 1993, p 323).

The male of *S. pulchellus* without setae $h_3$ on the suranal shield; trochanteral chaetotaxy of the male 1, 1, 2, 0 and that of the female 1, 1, 2, 1; genital chaetotaxy of the male 5($\kappa$), 3, 0, 0 and that of the female 6($\kappa$), 5, 2, 2; the female bears 4 aggenial setae and the male bears 3 aggenital setae.

Males of genus *Stigmaeus* differ from females in that they have aedeagus, two solenidia ($\omega$) on tarsi I-IV, the body smaller; setae $ps_{1,2}$ reduced and peg-like, dorsal setae shorter, genital and anal openings fused and genital setae absent. The leg chaetotaxy and the number of aggenital setae can be identical or different in the female and male. These charac-ters can be used for identification of the male of *Stigmaeus*.

The males of *S. brevisetis*, *S. candicus* and *S. pulchellus* are with fewer setae on the segments of the legs than the females. The male of *S. kumalariensis* leg chaetotaxy and the number of aggenital setae are the same with those of the adult female.

The nymphal stages of *Stigmaeus* differ from the females mainly in a reduction of leg setae. The deuonymph differs in the absence of genital folds and trochanter IV nude (Fan and Zhang 2005). The pronotonymph lacks seta $da$, one subcapitular seta.
and has fewer setae in aggenital area (Fan and Zhang 2005).

REFERENCES


Oudemans A.-C. 1931 — Acarologische aanteekeningen CVIII — Entomologische Berichten Amsterdam, 8(179): 251-263.


Uluçay I.

COPYRIGHT

Uluçay I. Acarologia is under free license. This open-access article is distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.