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Five new species of *Ceratoppia* (Acari: Oribatida: Peloppiidae) from western North America

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Abstract

I present the systematics and distribution of five new species of oribatid mites in the genus *Ceratoppia* (Oribatida: Peloppiidae) from western North America. The species are described on the basis of adult morphology using the following character states: number of hypostomal setae, number, length and expression of posterior notogastral setae, length of lamellae and lamellar cusp, length of interlamellar setae, and the shape and dentition of the rostrum. *Ceratoppia indentata* **n. sp.** is described from forest floor habitats, while *Ceratoppia longicuspis* **n. sp.** and *Ceratoppia tofinoensis* **n. sp.** are described from arboreal bryosphere habitats; *Ceratoppia offarostrata* **n. sp.** is associated with bark habitats. *Ceratoppia valerieae* **n. sp.** was collected from both arboreal and forest floor samples. Distributions of all species are provided based on museum and collection records; *C. indentata*, *C. longicuspis*, *C. tofinoensis* are recorded from coastal temperate coniferous rainforests of the Pacific Northwest of North America, while *C. valerieae* was found in coastal temperate rainforests and extending along the southern border of British Columbia into eastern Alberta. *Ceratoppia offarostrata* is collected only from a small number of locations on the west coast of Canada. Comments on other North American *Ceratoppia* species is given. A morphological key is presented to the described adult species for the genus *Ceratoppia* in North America.

Key words: arboreal habitats, *Ceratoppia*, Oribatida, Pacific Northwest, Peloppiidae, temperate rainforest, western North America

Introduction

The genus *Ceratoppia* Berlese, 1908 (Acari: Oribatida: Peloppiidae) has 18 described extant species and subspecies world–wide (Schatz 2004, Subías 2009). The genus is limited to the northern hemisphere, with species having mainly Holarctic distributions, although Schatz (2006) reported unidentified *Ceratoppia* from Costa Rica and Panama subalpine and montane sites. In North America there are four recorded species: *Ceratoppia bipilis* (Hermann, 1804), *Ceratoppia quadridentata* (Haller, 1882), *Ceratoppia sexpilosa* Willmann, 1938, and *Ceratoppia sphaerica* (L. Koch, 1879), and two subspecies; *C. bipilis spinipes* (Banks, 1906) and *C. quadridentata arctica* Hammer, 1955 (Marshall *et al.* 1987). However, the validity of the subspecies *C. quadridentata arctica* and *C. bipilis spinipes* is questionable, as variation in many characters, such as the length of lamellar cusps, used to differentiate species from subspecies may be due to geographical variation and ecology (Grandjean 1936).

The two main character states differentiating North American species of *Ceratoppia* are the number of hypostomal setae on the subcapitular mentum, and the number and expression of posterior notogastral setae. Other diagnostic characters include the length of the lamellae and shape of the rostrum. *Ceratoppia bipilis* and its subspecies *C. bipilis spinipes* are rare among *Ceratoppia* in having two pairs of hypostomal setae, which is considered a derived character state compared to one pair of setae (Grandjean 1936) which is found in the other previously described North American *Ceratoppia*. The genus *Ceratoppia* typically has two or three pairs of long, conspicuous posterior notogastral setae. The dominant form of setal expression is two pairs of posterior seta expressed (p_1, p_3) as found in *C. quadridentata*, *C. sphaerica* and *C. bipilis*, while the subdominant character state of three pairs of posterior notogastral seta expressed (h_1, p_2, p_3) is observed in *C. sexpilosa* (Seniczak & Seniczak 2010). Among *Cer-*

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atoppia, the length of the lamellae either reach the insertion of the rostral setae or are much shorter; the rostrum can be pointed, rounded yet dentate, or incised.

Described species of *Ceratoppia* in North America have been recorded in low abundance in subarctic regions (Hammer 1955); *C. quadridentata* and *C. bipilis* additionally occur in northern boreal forest organic soils across Canada, and temperate areas in eastern North America. The genus *Ceratoppia* has been recorded in western temperate North America previously (Moldenke & Fichter 1988, Lindo & Winchester 2006), but species have remained unidentified. The fauna of western North America, and in particular coastal temperate rainforests of the Pacific Northwest, are shown to have high oribatid mite species richness (Lindo & Winchester 2008) with many species endemic to the region. Many new species have been described in recent years (Behan-Pelletier 2000, Behan-Pelletier *et al.* 2001, Behan-Pelletier *et al.* 2002, Behan-Pelletier *et al.* 2005, Lindo *et al.* 2008), including a new species of *Dendrozetes* in the family Peloppiidae (Lindo *et al.* 2010). Pacific Northwest forest habitats appear to have high relative diversity of the family Peloppiidae including the genera *Ceratoppia*, *Dendrozetes*, *Metrioppia* and *Parapyroppia*.

In this paper I describe five new species of *Ceratoppia* from western North America based on adult specimens collected from coastal temperate rainforests on Vancouver Island, British Columbia, Canada. Species are differentiated from previously described North American *Ceratoppia* by the following character states: number of hypostomal setae; number, length and expression of posterior notogastral setae; length of lamellae and lamellar cusps; length of interlamellar and lamellar setae; the shape and dentition of the rostrum. Three species are described primarily or solely from arboreal habitats based on specimens collected in moss mats and suspended soils (the arboreal bryosphere, *sensu* Lindo & Gonzalez 2010), one species is collected solely from bark habitats, and one species collected solely from forest floor soils. In addition to describing the external morphology of the adults, I provide distributional maps for the new species based on previously collected samples and specimens from western Canada (Yukon Territory, British Columbia, Alberta) and western United States (Alaska, Washington, Oregon, California). Based on adult morphology, I provide a key to the known *Ceratoppia* species of North America; character states of *Ceratoppia* are incorporated into a new diagnosis of the genus.

Material and methods

Species description. Morphological terminology is mostly that of F. Grandjean (see Travé and Vachon (1975) for general references, Norton (1977) for leg setal nomenclature, and Norton & Behan–Pelletier (2009), for overview). The following conventions of measurements and description are used: *total length*, measured dorsally from tip of the rostrum to posterior edge of the notogaster on specimens in lactic acid in cavity slides; *total width*, measured at the widest part of the notogaster, perpendicular to the circumgastric scissure on specimens in lactic acid in cavity slides; *prodorsal setae*, measured on dissected slide–mounted specimens; *ro*, rostral setae; *le*, lamellar setae; *in*, interlamellar setae; *ex*, exobothridial setae; *bo*, bothridial seta. The unideficient nomenclature is used for the notogastral setation. Setal measurements are averaged from 10–20 specimens. Average measurements for the five species are summarised in Table 1.

Abbreviations for collections of Acari are as follows:

CNC	Canadian National Collection of Insects,Arachnids and Nematodes, Agriculture and Agri–Food Canada, Ottawa, Ontario, Canada
PFC	Pacific Forestry Centre of the Canadian Forestry Service, Natural Resources Canada, Victoria, British Columbia, Canada
RNC	Personal collection of Dr. Roy Norton
ZLC	Personal collection of Dr. Zoë Lindo

TABLE 1. Comparison of morphological characters (average lengths in µm).

		Ceratoppia indentata **n. sp.**	*Ceratoppia longicuspis* **n. sp.**	*Ceratoppia tofinoensis* **n. sp.**	*Ceratoppia valerieae* **n. sp.**	*Ceratoppia offarostrata* **n. sp.**
	Total length (range)	606 (560–650)	705 (600–770)	563 (530–580)	622 (540–670)	606 (570–640)
	Notogastral width (range)	364 (340–380)	436 (370–480)	328 (310–340)	372 (300–410)	353 (300–390)
	Length : width	1.67	1.62	1.72	1.68	1.74
	Rostral setae	77	90	70	82	80
	Lamellar setae	94	52	97	93	109
	Distance between lamellae*	41	102	58	64	60
	Interlamellar setae	144	276	216	206	259
	Bothridial setae	191	140	135	126	161
	Lamellae cusp length	91	185	70	73	61
	Lamellae total length	228	288	192	200	220
Notogastral setae	h_1	103	.	.	.	.
	p_1	.	23	13	22	55
	p_2	.	5	.	.	.
	p_3	78	19	27	15	46
Subcapitular setae	a	27	36	28	29	31
	h	36	45	53	46,48	52
	m	38	48	44	44	38
Epimeral setae	1a	25	43	33	34	35
	1b	47	77	71	62	78
	1c	75	76	68	67	93
	2a	25	39	32	33	32
	3a	24	30	26	27	21
	3b	61	104	74	76	94
	3c	.	25	24	25	21
	4a	27	35	30	38	37
	4b	25	34	29	31	35
	4c	25	25	24	29	21
Ventral setae	g	20	25	20	25	20
	an	22	18	13	16	21
	ag	24	25	21	20	21
	ad_1	53	25	29	28	34
	ad_2	42	26	27	29	30
	ad_3	26	23	20	24	24
	egg #	4	11	3	4	4
	egg length	259	235	264	256	280
	egg width	101	109	112	113	130

*as measured at base of cusps.

Systematics

Genus *Ceratoppia* Berlese, 1908

Type species: *Notaspis bipilis* Hermann, 1804, p. 7.

Diagnosis. Adults of the genus *Ceratoppia* are unique among the Peloppiidae in having the following combination of character states: chelicerae chelate–dentate; sejugal apodeme conspicuous, straight; legs heterotridactylous; lamellae parallel with thin, projecting, well defined cusps; bothridial setae elongate, typically setiform (clavate in *C. clavisensillata*); notogaster rounded; two or three pairs of posterior notogastral setae often prominent; dorsophragma and pleurophragma absent; pedotecta I and II well–developed; dorsal side of pedotecta I with prominent blade–like tooth extending anteriorly; lateral ridge extending from base of acetabula I to rostrum; humerosejugal porose areas absent; apodeme IV transverse, curving around genital plate, with furrow and minitectum present anteriorly, incomplete adjacent to genital plate; six pairs of genital setae; three pairs of adanal setae of which ad_1 and ad_2 subequal in shape; palp setal formula 0–1–2–3–9(1); *acm* closely associated with solenidion on palptarsus; axillary saccule of subcapitulum absent; porose areas dorsolateral and antiaxial on femora of all legs, and trochanters III, IV.

Ceratoppia indentata n. sp.

Material examined. Holotype: Adult female. Canada, British Columbia, Vancouver Island, Upper Walbran Valley (48°39'N, 124°35'W), 10 September 2004 (Z. Lindo) from forest floor below western redcedar (*Thuja plicata* D. Don); deposited in the Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario, Canada (CNC), type No. 23974. Paratypes: ten with same data as holotype. Canada, British Columbia, Vancouver Island: Upper Carmanah Valley (48°44'N, 124°37'W), 3 July 1990 (N.N. Winchester), ten from forest floor below Sitka spruce (*Picea sitchensis* (Bong.) Carr.). USA: Washington, Hoh Valley, Olympic National Park (47°52'N, 123°54'W), 10 September 1983 (A. Fjellberg), seven from litter and humus below Sitka spruce. Oregon, Curry County, Alfred A. Loeb State Park (42°6'N, 124°11'W), 12 August 1985 (E.E. Lindquist), 11 from moss and lichen around tan-oak and willow trunks; Oregon, Lane County, H.J. Andrews Experimental Forest, Willamette National Forest (44°10'N, 123°13'W), 15 May 1984 (D.S. Chandler), 18 from rotting logs on forest floor. Paratypes deposited in the CNC, PFC, RNC, and ZLC.

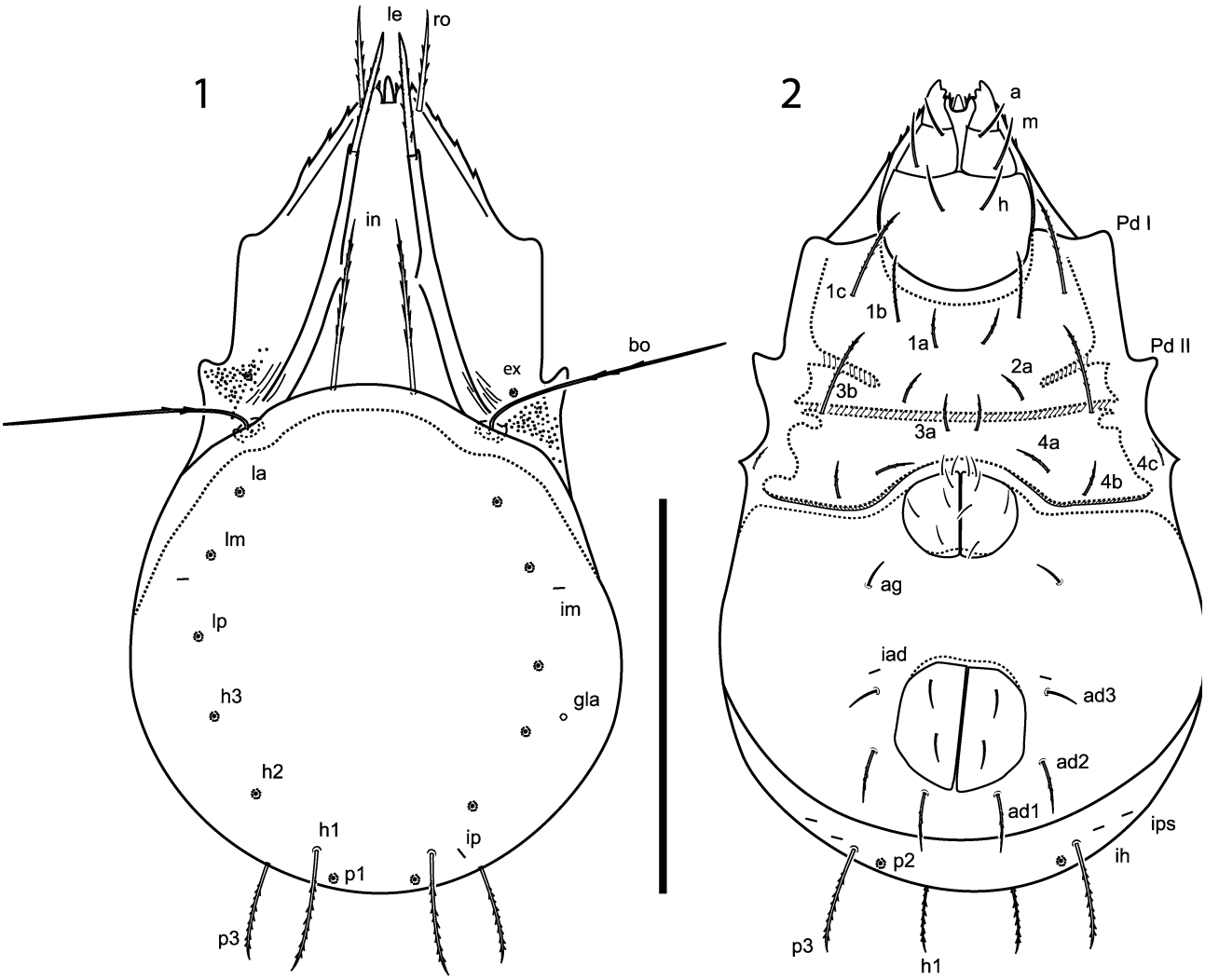
Other material examined. Canada, British Columbia: Caycuse (48°53'N, 124°21'W); Broken Island Group (48°52'N, 12419'W); Barkley Sound (48°58'N, 124°6'W); Bamfield Marine Station (48°45'N, 125°10'W); Hesquiat Peninsula Provincial Park (49°22'N, 126°31'W); Sydney Inlet, Clayoquot Sound (49°30'N, 126°17'W); Campbell River, STEMS Research site (50°03'N, 125°26'W); Brooks Peninsula (50°7'N, 127°46'W); Lax Kw'alaams (54°33'N, 131°25'W). USA, Washington: Quinault Rain Forest, Olympic National Forest (47°32'N, 123°40'W); Queets River, Olympic National Park (47°32'N, 124°21'W). Oregon: Tillamook State Forest (45°30'N, 123°39'W); Siuslaw National Forest (44°21'N, 123°48'W); Alsea Falls (44°20'N, 123°31'W); Mary's Peak Botanical Special Interest Area (44°30'N, 123°32'W); Siskiyou National Forest (42°30'N, 123°57'W). California: Jedediah Smith Redwood State Park (41°46'N, 124°5'W); Angelo Coast Range Reserve (39°40'N, 123°39'W); Van Damme Beach State Park (39°16'N, 123°43'W); Salt Point State Park (38°57'N, 123°32'W); Purisima Creek Redwoods Regional Open Space near Halfmoon Bay (37°24'N, 122°21'W).

Etymology. This species is named for the deeply indented rostrum with large, single, inset medial denticle.

Diagnosis. Adult. Total length 560–650 µm, with character states of Peloppiidae (Grandjean 1954; as Ceratoppiidae), and character states of *Ceratoppia* as described above. This species can be differentiated from other *Ceratoppia* by the presence of a distinct invaginated rostrum with a thin, somewhat flexible, medial denticle, and many lateral denticles; interlamellar setae distinctly shorter than the lamellae, only reaching the base of the lamellar cusps; one pair of hypostomal setae; lamellae not reaching the insertion of the rostral setae.

Description. Adult. (Figs. 1–7)

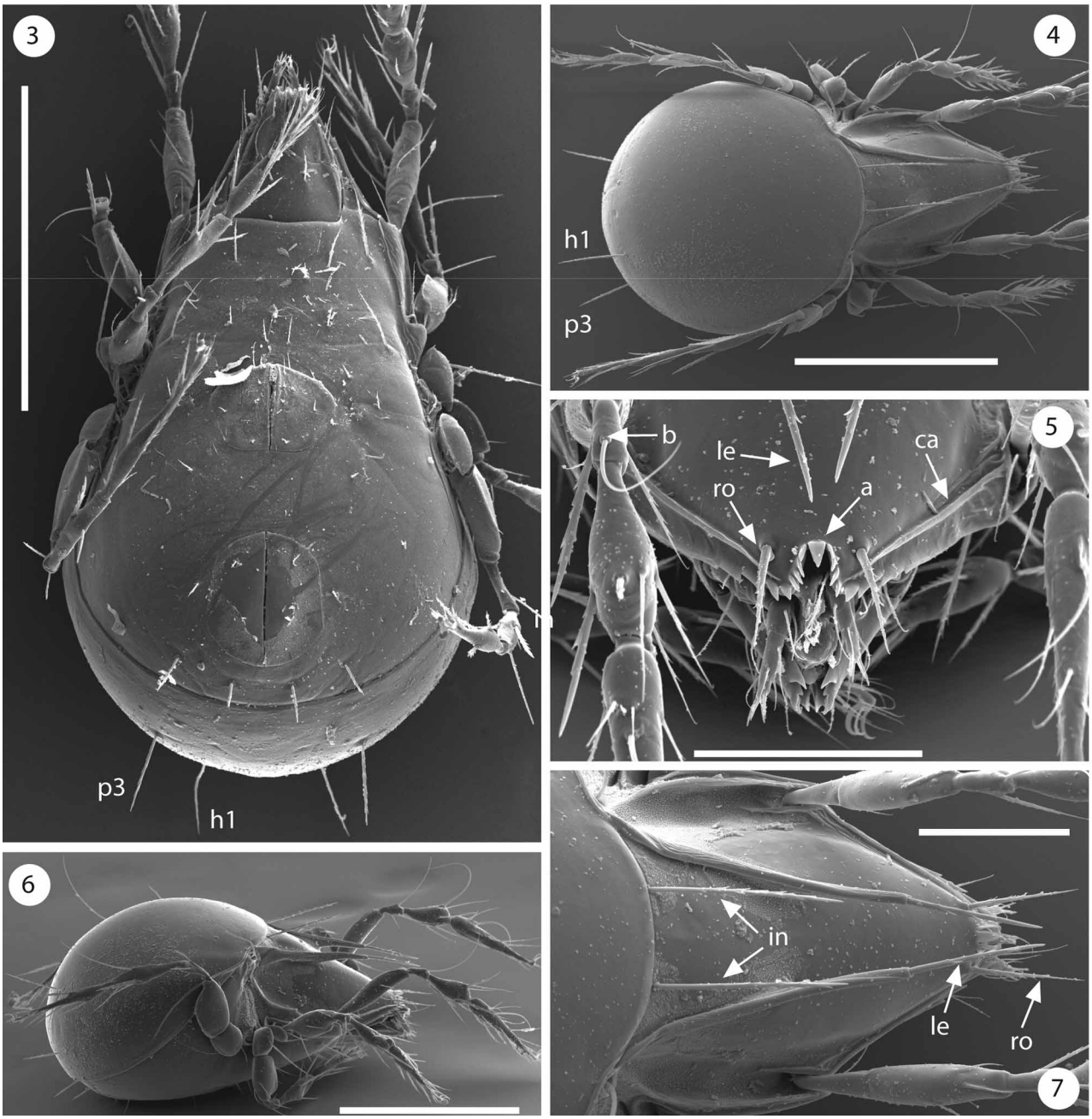
Measurements: Mean total length: females (n = 5) 628 µm (range 600–650); males (n = 5) 584 µm (range 560–600) (Figs. 1–2). Mean notogastral width: females (n = 5) 376 µm (range 360–380); males (n = 5) 352 µm (range 340–380).



FIGURES 1–2. *Ceratoppia indentata* **n. sp.**, adult female. **1**, Dorsal aspect; **2**, Ventral aspect. Legs removed. For description of setae see Materials and methods. Scale bars = 300 µm.

Integument: Smooth to microtuberculate. Integument laterad of bothridial setae between acetabula III and IV tuberculate. **Prodorsum:** Rostrum strongly indented (18 µm deep × 13 µm wide), with single sub–triangular medial denticle at base of indentition and 7–11 sharp denticles along margin and laterally (Fig. 1, Fig. 5). Lateral ridge extending from base of acetabulum I to rostrum (Fig. 5). Seta *ro* 68–83 µm long, thick, acuminate, barbed, extending well beyond rostrum (Fig. 1, Figs. 5, 7). Lamella about 227 µm long to end of cusps, not reaching insertion point of *ro*, striate at base (Fig. 7). Lamellar cusps about 91 µm long with small lateral denticle. Seta *le* about 94 µm long, thick, barbed, inserted medially on lamellar cusp and extending anteriorly beyond rostrum (Fig. 7). Seta *in* barbed, 144 µm long, not reaching tip of lamella (Fig. 1, Fig. 7). Mutual distance of setal pairs *ro–ro*, *le–le*, and *in–in*, about 47, 40, and 66 µm, respectively. Seta *ex* not observed; alveoli well removed anteriolaterally from bothridia (Fig. 1). Bothridial seta 191 µm long, thin with long barbs, tapering to point. **Lateral aspect of prodorsum:** Pedotectum I well developed, dentate anteriorly, with dorsal cusp about 20 µm. **Notogaster:** Subequal length to width; hysterosoma often fattened with 1–7 eggs of considerable size (about 260 µm long). Notogastral setae reduced to alveoli, except for two pairs of posterior setae (Fig. 1, Figs. 3–4). Alveoli with porose areas (Fig. 1). Posterior notogastral setae h_1, about 103 µm long (range 75–118, n = 13), barbed; setae p_3 about 78 µm long (range 60–95, n = 16), barbed; p_1 alveoli well removed posteriorly and mediad to h_1; p_2 alveoli mediad to p_3. Lyrifissures *im*, *ip*, *ih*, and *ips* present, all about 10 µm long. **Ventral region:** Apodeme IV forming shallow furrow with minitectum on anterior portion (Fig. 2), thinning near genital aperture as described by Grandjean (1970). Epimeral setae smooth or with a few barbs, acuminate, relatively long; formula (epimeres I to IV) 3–1–2–3 (Fig. 2). Setae lengths as follows: *1a*, *1b*, *1c* about 25, 47, 75 µm, respectively, *2a*, *3a*, *3b*, about 25, 24, 61, µm, respectively, and *4a*, *4b*,

4c about 27, 25 and 25 µm, respectively. Six pairs of genital setae ranging in length from 15–25 µm, with longest g_4 and g_5, setose. Aggenital seta about 22 µm long, setose, asymmetry observed in a single specimen (two pairs of aggenital setae on right side). Two pairs of anal setae about 22 µm long, asymmetry observed in single specimen with three pairs of anal setae on left side. Three pairs of adanal setae; ad_3 about 26 µm, thin, barbed, different from ad_1 and ad_2 which are thicker, barbed, about 51 and 41 µm long, respectively (Fig. 2, Fig. 3). Lyrifissure *iad* 8 µm long, anterior to ad_3. **Gnathosoma:** Subcapitular mentum without tectum; one pair of setae *h* about 36 µm long; gnathosomal setae *m* 38 µm long, and setae *a* about 27 µm long.



FIGURES 3–7. *Ceratoppia indentata* **n. sp.**, scanning electron microscope images of adult. **3**, habitus, ventral aspect; **4**, habitus, dorsal aspect (setae h_1 of left side broken); **5**, rostrum, anterio–dorsal aspect, showing indented rostrum (a) with teeth, minute stub of seta *d* on genu leg I (b), rostral setae (*ro*), lamellar setae (*le*), and lateral carina (ca); **6**, habitus, lateral aspect; **7**, prodorsum in dorsal aspect, interlamellar setae (*in*), lamellar setae (*le*), and rostral setae (*ro*). Scale bars = 300 µm (Figs. 3–4, 6) and 100 µm (Fig. 5, 7).

Legs: Ratio of leg IV to body length about 0.7:1. Approximate lengths of leg segments (femur, genu, tibia, tarsus; in µm): I 156, 38, 83, 165; II 128, 28, 83, 138; III 72, 36, 100, 133; IV 87, 63, 124, 176. Pretarsus tridactylous

with large smooth empodial and slightly thinner lateral claws. Setation (I–IV, number of solenidia in parentheses): trochanters 1–1–2–1; femora 5–4–3–2; genua 4(1)–3(1)–2(1)–3; tibiae 4(2)–4(1)–3(1)–3(1); tarsi 20(2)–15(2)–15–12; setation indicated in Table 2. Seta *d* retained as a small stub on genua leg I (Fig. 5), but absent from tibiae of adult; no evidence of retention associated with socket of solenidion $_1$, as illustrated for *Ceratoppia bipilis* (Grandjean 1935). Leg I genua setae *l"* thick, barbed and spinose compared to other leg I setae (Fig. 5). Leg I tarsal solenidia ω_1 and ω_2 thin, flagellate. All tarsal setae barbed except *p* which is simple, straight, short on leg I, increasing in length and becoming curved, almost flagellate on subsequent legs.

TABLE 2. Leg setation.

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg 1	*v'*	*d bv" (l) v'*	*d* (l) v' σ*	*(l) (v) d‡ φ*$_{1\ 2}$	*(ft)(pl)(tc)(p)(u) s (a)(pv) e* ω_1 ω_2 *(it)(v)*
Leg 2	*v'*	*d bv" (l)*	*l' (v) σ*	*(l) (v) φ*	*(ft)(tc)(p)(u) s (a)(pv)* ω_1 ω_2 *(it)*
Leg 3	*v' l'*	*d ev' l'*	*l' v' σ*	*l' (v) φ*	*(ft)(tc)(p)(u) s (a)(pv)(it)*
Leg 4	*v'*	*d ev'*	*l' v'*	*l' (v) φ*	*ft" (tc)(p)(u) s (a)(pv)*

**d* setae present in *Ceratoppia indentata* and *C. valerieae*, retained as small stub.
‡*d* setae present in some specimens of *C. indentata* and *C. valerieae*, associated with solenidia φ_1.

Remarks. *Ceratoppia indentata* **n. sp.** is similar to *C. incisa* Kaneko & Aoki, 1982 with interlamellar setae distinctly shorter than the lamellae, only reaching the base of the lamellar cusps, and a distinct invaginated rostrum. *Ceratoppia indentata* **n. sp.** differs from *C. incisa* by having longer, barbed posterior setae (h_1, p_3), barbed epimeral setae, longer lamellar and rostral setae, shorter lamellae not reaching the insertion of the rostral setae, and in the shape of the rostral incision. *Ceratoppia incisa* rostral indentation is described as having two incisions, the bottoms of which are broadly rounded (Kaneko & Aoki 1982), whereas *C. indentata* clearly has a single invagination of the rostral margin, with a thin, somewhat flexible, medial denticle, and many lateral denticles. *Ceratoppia indentata* has an unusual pattern of notogastral expression in that *h1* rather than *p1* are expressed in conjunction with p_3. The dominant form of notogastral expression among the *Ceratoppia* is two pairs of posterior seta (p_1 and p_3) expressed with h_1, alveolus, but three pairs of posterior notogastral seta expressed (h_1, p_2, p_3) is observed in *C. sexpilosa* (Seniczak & Seniczak 2010). In both *C. bipilis* and *C. quadridentata arctica*, the h_1 alveolus is directly anterior and dorsal to p_1, while in *C. indentata* the p_1 alveoli are well removed posteriorly and mediad to h_1. Therefore it is unlikely that p_1 and h_1 setae are simply shifted in position. It is more likely that the posterior notogastral seta expression of *C. indentata* is derived from the subdominant form of expression with p_2 secondarily lost.

Distribution. *Ceratoppia indentata* **n. sp.** is the dominant *Ceratoppia* on the forest floor throughout most of the Pacific Northwest coastal temperate rainforest biogeoclimatic zone. Widely distributed and abundant on Vancouver Island, British Columbia, Canada, the distribution extends southward through to northern California, remaining relatively coastal. The H.J. Andrews Experimental Forest in Oregon appears to be the most inland site where *C. indentata* has been observed, where it was recorded (as *Ceratoppia* sp.) as frequent, but never abundant (Moldenke & Fitcher 1988 – see their Figs. 205–207). Northern records appear less common, but *C. indentata* is recorded from the north coast of British Columbia (Lax Kw'alaams, Port Simpson). Species in the southern range appear with morphological variation; specimens observed from California are larger and darker than northern specimens, interlamellar setae are relatively slightly longer, and posterior setae p_1 are relatively slightly shorter. Loeb State Park, in southern Oregon has both variants co–occurring. The habitat of *Ceratoppia indentata* **n. sp.** appears to be mixed or single litter from both conifer and deciduous trees, moss, and lichens; often collected near beaches, small creeks, river mouths or ravines suggests a moist habitat preference.

Ceratoppia longicuspis n. sp.

Material examined. Holotype: Adult female. Canada, British Columbia, Vancouver Island, Upper Walbran Valley (48°39'N, 124°35'W) 5 September 2005 (Z. Lindo) from suspended soil at 35 m in canopy of western redcedar

(*Thuja plicata* D. Don); deposited in the CNC, type No. 23975. Paratypes: 20 with same data as holotype. Canada, British Columbia, Vancouver Island: Upper Carmanah Valley (48°44'N, 124°37'W), 3 July 1990 (N. Winchester), two from moss in canopy of Sitka spruce (*Picea sitchensis* (Bong.) Carr.); Cowichan Lake (48°50'N, 124°10'W), 16 June 1979 (I.M. Smith), four from damp litter near creek. USA, Oregon, Benton County, Mary's Peak Botanical Special Interest Area (44°30'N, 12332'W), 28 June 1983 (I.M. Smith), eight from foliage sweepings. Paratypes deposited in the CNC, PFC, RNC, and ZLC.

Other material examined. Canada, British Columbia, Vancouver Island: Moyeha Watershed, Clayoquot Sound (49°24'N, 125°54'W); Bamfield Marine Station (48°45'N, 125°10'W); Hwy 19, 26 km N of Hwy 28 (50°14'N, 125°34'W); Pacific Rim National Park (49°0'N, 125°36'W); Heather Mountain (48°57'N, 124°28'W); Caycuse (48°53'N, 124°21'W); Goldstream Provincial Park (48°28'N, 123°32'W); Brooks Peninsula (50°7'N, 127°46'W). British Columbia: Winter Inlet, Pearse Island (54°49'N, 130°26'W); Newcombe Harbour, Pitt Island (53°43'N, 130°5'W); Graham Island, Haida Gwaii (53°29'N, 130°20'W); Tweedsmuir South Provincial Park (53°4'N, 126°16'W). USA, Oregon: Tillamook State Forest (45°30'N, 123°39'W); Siuslaw National Forest (44°21'N, 123°48'W); Alsea Falls (44°20'N, 123°31'W); H.J. Andrews Experimental Forest, Willamette National Forest (44°10'N, 123°13'W); Mt. Hood National Forest (45°35'N, 122°4'W); Siskiyou National Forest (42°30'N, 123°57'W); Burnt Hill (42°14'N, 124°23'W). California, Salt Point State Park (38°57'N, 12332'W).

Etymology. This species is named for the relatively long length of the lamellar cusps.

Diagnosis. Adult. Total length 600–770 µm, with character states of Peloppiidae (Grandjean, 1954; as Ceratoppiidae), and character states of *Ceratoppia* as described above. This species can be differentiated from other *Ceratoppia* by the presence of three pairs of very small posterior setae (p_1, p_2, p_3), in particular setae p_2 minute, often not discernable; lamellae long, reaching insertion of rostral setae, with 2/3 free cusps; lamellar setae much shorter than rostral setae; large medial rostral tooth with lateral denticles; interlamellar setae long, reaching ends of lamellae; one pair of hypostomal setae.

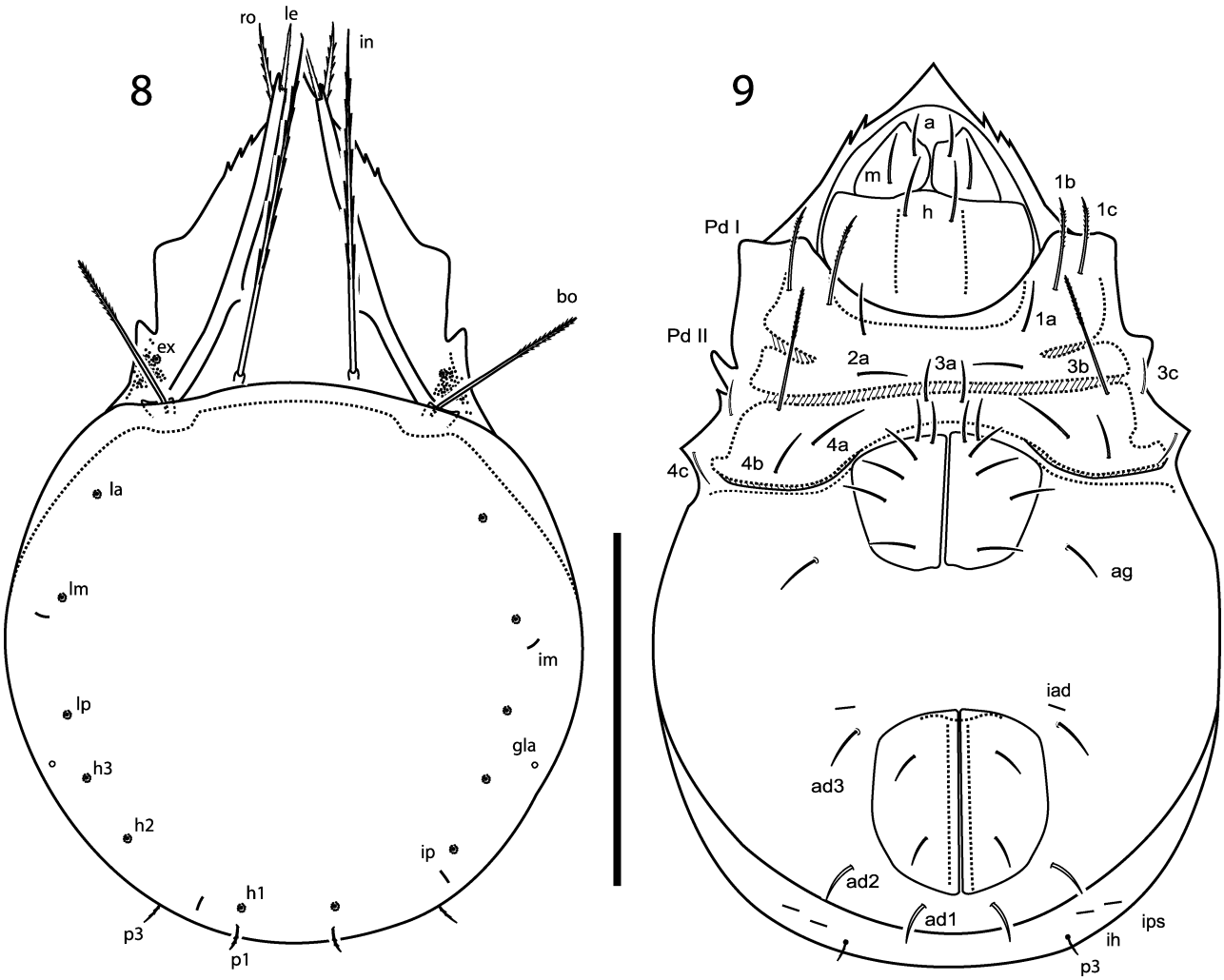
Description. Adult. (Figs. 8–15)

Measurements: Mean total length: females (n = 6) 735 µm (range 690–770); males (n = 4) 660 µm (range 600–700) (Figs. 8–10). Mean notogastral width: females (n = 6) 460 µm (range 430–480); males (n = 4) 400 µm (range 370–420).

Integument: Smooth to microtuberculate. Integument laterad of bothridial setae between acetabula III and IV tuberculate. **Prodorsum:** Rostrum with large triangular rostral tooth and one or two lateral teeth, well posterior to rostrum (Fig. 12). Seta *ro* 85–103 µm long, barbed, tapering to a sharp point, extending well beyond rostrum (Figs. 1, 11). Lamellae about 284 µm long to end of cusps, reaching well beyond insertion of *ro* (Fig. 12). Lamellar cusps about 183 µm long with large lateral denticle (Fig. 11). Seta *le* about 51 µm long, barbed, tapering, extending anteriorly beyond rostrum. Seta *in* barbed, 277 µm long, extending anteriorly just to or beyond tips of lamellae (Figs. 12, 14). Mutual distance of setal pairs *ro–ro*, *le–le*, and *in–in*, about 45, 102 (variable), and 86 µm, respectively. Seta *ex* not observed; alveoli well removed anteriolaterally from bothridia (Fig. 8). Bothridial seta 138 µm, thick, barbed. **Lateral aspect of prodorsum:** Pedotectum I well developed, dentate anteriorly, with dorsal cusp about 20 µm (Fig. 14). **Notogaster:** Subequal length to width, (ratio l:w = 1.01:1); hysterosoma often fattened with 6–21 eggs of considerable size (about 237 µm long). Notogastral setae reduced to alveoli, except for three pairs of posterior setae. Alveoli h_1 variable in position. Posterior notogastral setae p_1, about 23 µm long (range 15–28, n = 14), minutely barbed (Figs. 10, 14); setae p_2 present, very small, about 5 µm, setose (Fig. 15), not discerned on all specimens; setae p_3 about 19 µm long (range 13–30, n = 12), minutely barbed (Figs. 13–15). Lyrifissures *im*, *ip*, *ih*, and *ips* present, all about 10 µm long. **Ventral region:** Apodeme IV forming shallow furrow with minitectum on anterior portion, thinning near genital aperture. Coxisternal setae smooth or with a few barbs, acuminate, relatively long; formula (epimeres I to IV) 3–1–3–3. Setae lengths as follows: *1a*, *1b*, *1c* about 43, 77, 76 µm, respectively, *2a*, *3a*, *3b*, *3c* about 39, 30, 104, 25 µm, respectively, and *4a*, *4b*, *4c* about 35, 34 and 25 µm, respectively. Six pairs of genital setae ranging in length from 18–25 µm, with longest g_4 and g_5, setose. Aggenital seta about 26 µm long, setose. Two pairs of anal setae about 18 µm long, setose. Three pairs of adanal setae; ad_3 about 23 µm, simple to minutely barbed; ad_1 and ad_2 thicker, barbed, about 25 and 26 µm long, respectively (Fig. 15). Lyrifissure *iad* 8 µm long, anterior to ad_3. **Gnathosoma:** Subcapitular mentum without tectum; one pair of setae *h* about 45 µm long; gnathosomal setae *m* 48 µm long, and *a* about 36 µm long (Fig. 11).

Legs: Ratio of leg IV to body length about 0.7:1. Approximate lengths of leg segments (femur, genu, tibia, tarsus; in µm): I 144, 41, 89, 146; II 120, 27, 85, 137; III 86, 39, 115, 131; IV 96, 67, 149, 174. Pretarsus tridactylous

with large smooth empodial and slightly thinner lateral claws. Setation (I–IV, number of solenidia in parentheses): trochanters 1–1–2–1; femora 5–4–3–2; genua 3(1)–3(1)–2(1)–3; tibiae 4(2)–4(1)–3(1)–3(1); tarsi 20(2)–15(2)–15–12; setation indicated in Table 2. Seta *d* absent from genua and tibiae of adult, no evidence of retention associated with socket of solenidion φ_1, as illustrated for *Ceratoppia bipilis* (Grandjean 1935). Leg I genua setae *l"* thick and barbed compared to other leg I setae. Leg I tarsal solendia ω_1 and ω_2 subequal in length. All tarsal setae barbed except *p* which is simple, straight, short on leg I, increasing in length and becoming curved, almost flagellate on subsequent legs.

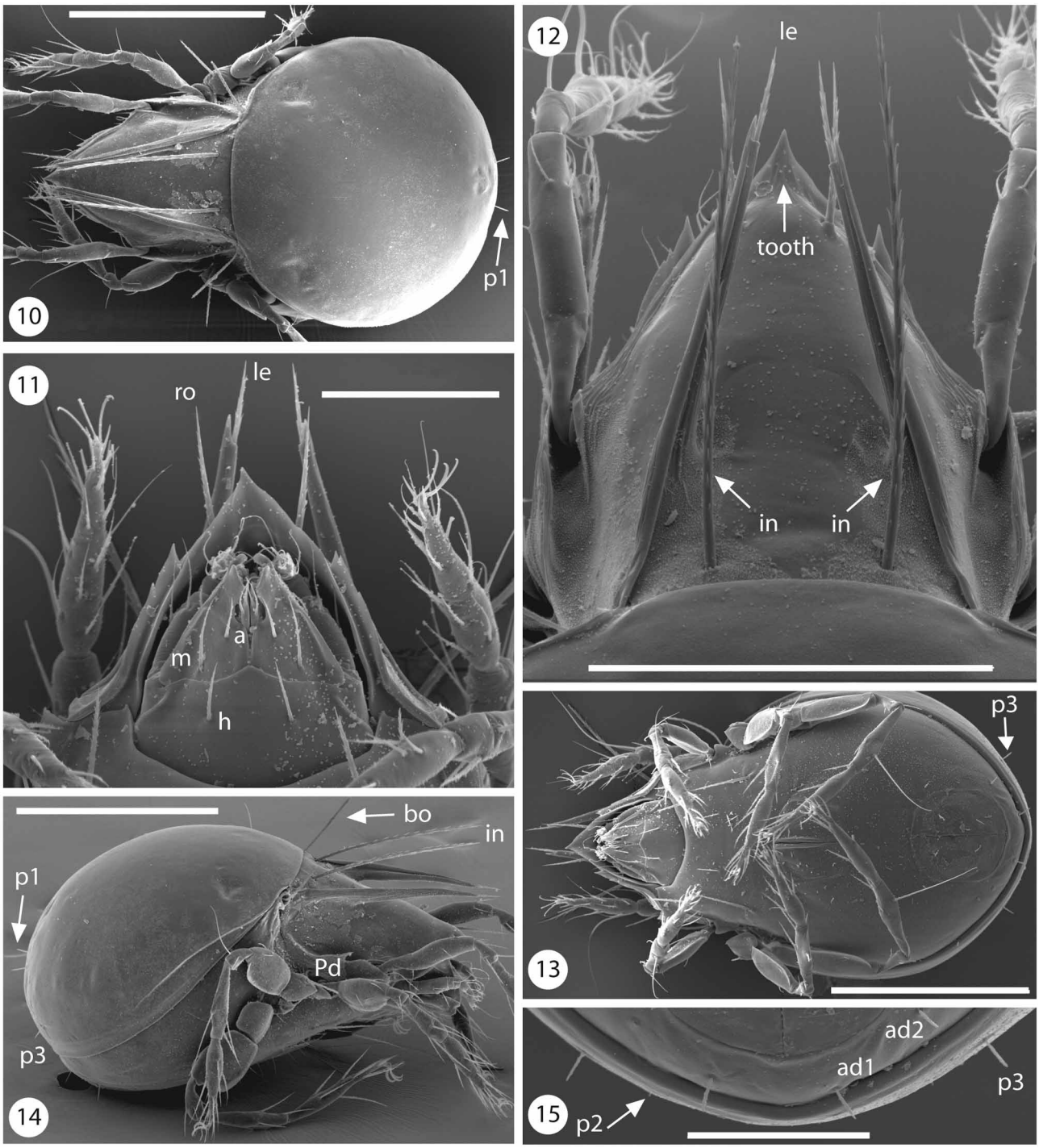


FIGURES 8–9. *Ceratoppia longicuspis* **n. sp.**, adult female. **8**, Dorsal aspect; **9**, Ventral aspect. Legs removed. For description of setae see Materials and methods. Scale bars = 300 µm.

Remarks: Rostral tooth of *C. longicuspis* **n. sp.** and cusps of lamellae prominent, generally larger and longer than other species of *Ceratoppia*. Possible similar but undescribed species from the east coast of Canada with large rostral tooth and long lamellar cusps with short lamellar setae. Patterns of posterior setal expression among the *Ceratoppia* reveal two main forms; a dominant state with two pairs of posterior seta (p_1 and p_3) expressed, and a subdominant combination of three pairs of posterior notogastral seta expressed (h_1, p_2, p_3) (Seniczak & Seniczak 2010). However, while *Ceratoppia longicuspis* posterior setal expression is similar to *C. sexpilosa* with three pairs of posterior setae, it is p_1 rather than h_1 that is expressed with p_2 and p_3. All setae are short, in particular, setae p_2 are minute and not observable in most specimens. A similar expression of *p*-series notogastral setae is found within the Gustavioidea in *Gustavia fusifer* (C.L. Koch, 1841) (Seniczak & Seniczak 2010).

Distribution: *Ceratoppia longicuspis* **n. sp.** is the dominant *Ceratoppia* in arboreal habitats, primarily epiphytic bryophytes, through most of the Pacific Northwest coastal temperate rainforest biogeoclimatic zone, but also co–occurring in lesser abundance in forest floor habitats with other *Ceratoppia* species described herein.

Widely distributed and abundant on Vancouver Island, British Columbia, Canada, the distribution extends southward through to northern California, and northward to Haida Gwaii (formerly Queen Charlotte Islands) and the north coastal of British Columbia (Pearse Island, Pitt Island, Tweedsmuir Provincial Park). *Ceratoppia longicuspis* has a mainly coastal distribution, but occurs occasionally in interior British Columbia, Washington and Oregon.



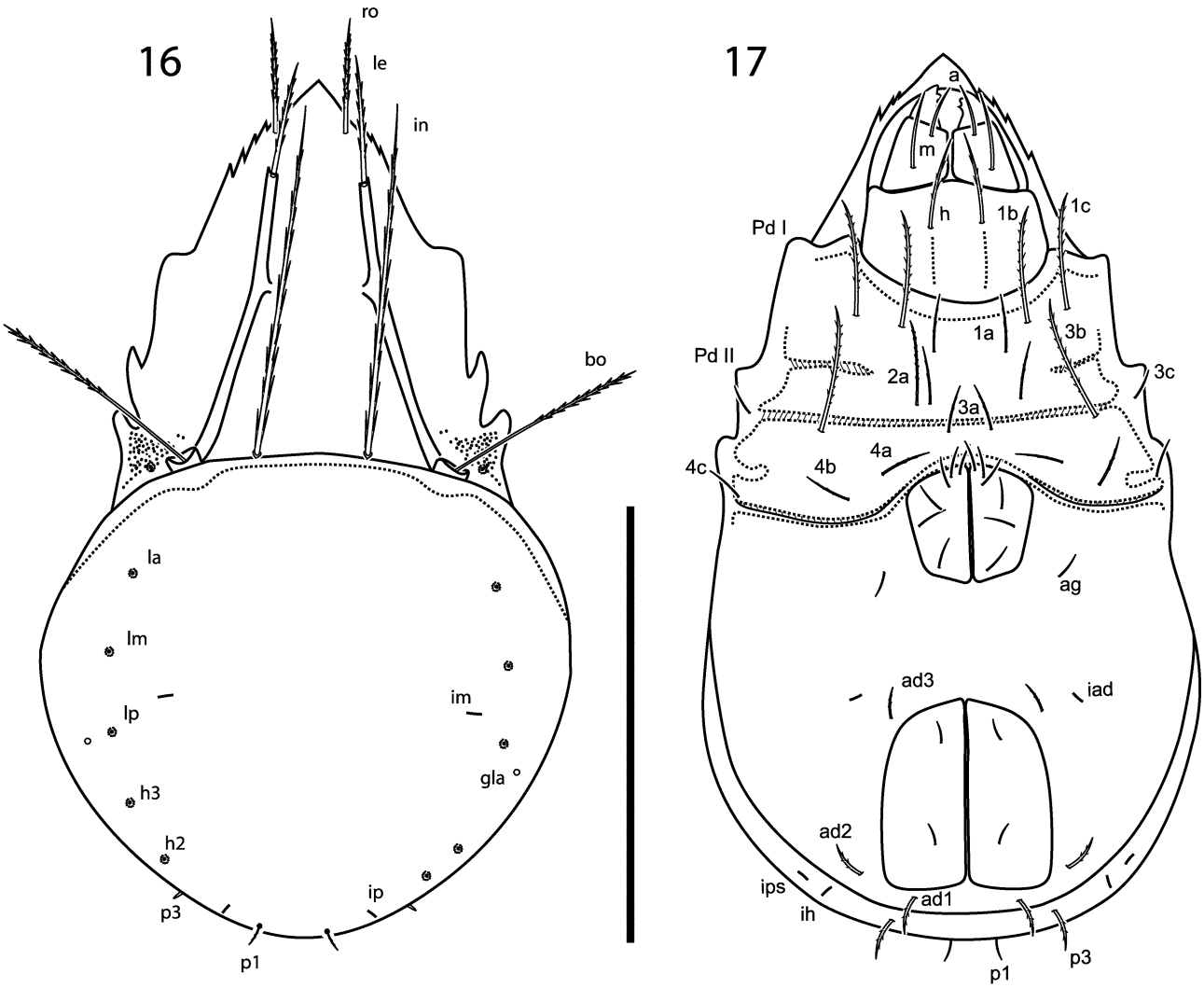
FIGURES 10–15. *Ceratoppia longicuspis* **n. sp.**, scanning electron microscope images of adult. **10**, habitus, dorsal aspect, posterior setae (p_1); **11**, gnathosoma, ventral aspect, gnathosomal setae (*a*), (*m*), hypostomal setae (*h*), lamellar setae (*le*), and rostral setae (*ro*); **12**, prodorsum in dorsal aspect, interlamellar setae (*in*), lamellar setae (*le*), and rostral tooth; **13**, habitus, ventral aspect, posterior setae (p_3); **14**, habitus, lateral aspect, bothridial setae (*bo*), interlamellar setae (*in*), posterior setae (p_1, p_3), pedotectum I (Pd); **15**, posterior ventral plate, ventral aspect, adanal setae (ad_1, ad_2), posterior notogastral setae (p_2, p_3). Scale bars = 300 µm (Figs. 10, 13, 14), 200 µm (Fig. 12), and 100 µm (Fig. 11, 15).

***Ceratoppia tofinoensis* n. sp.**

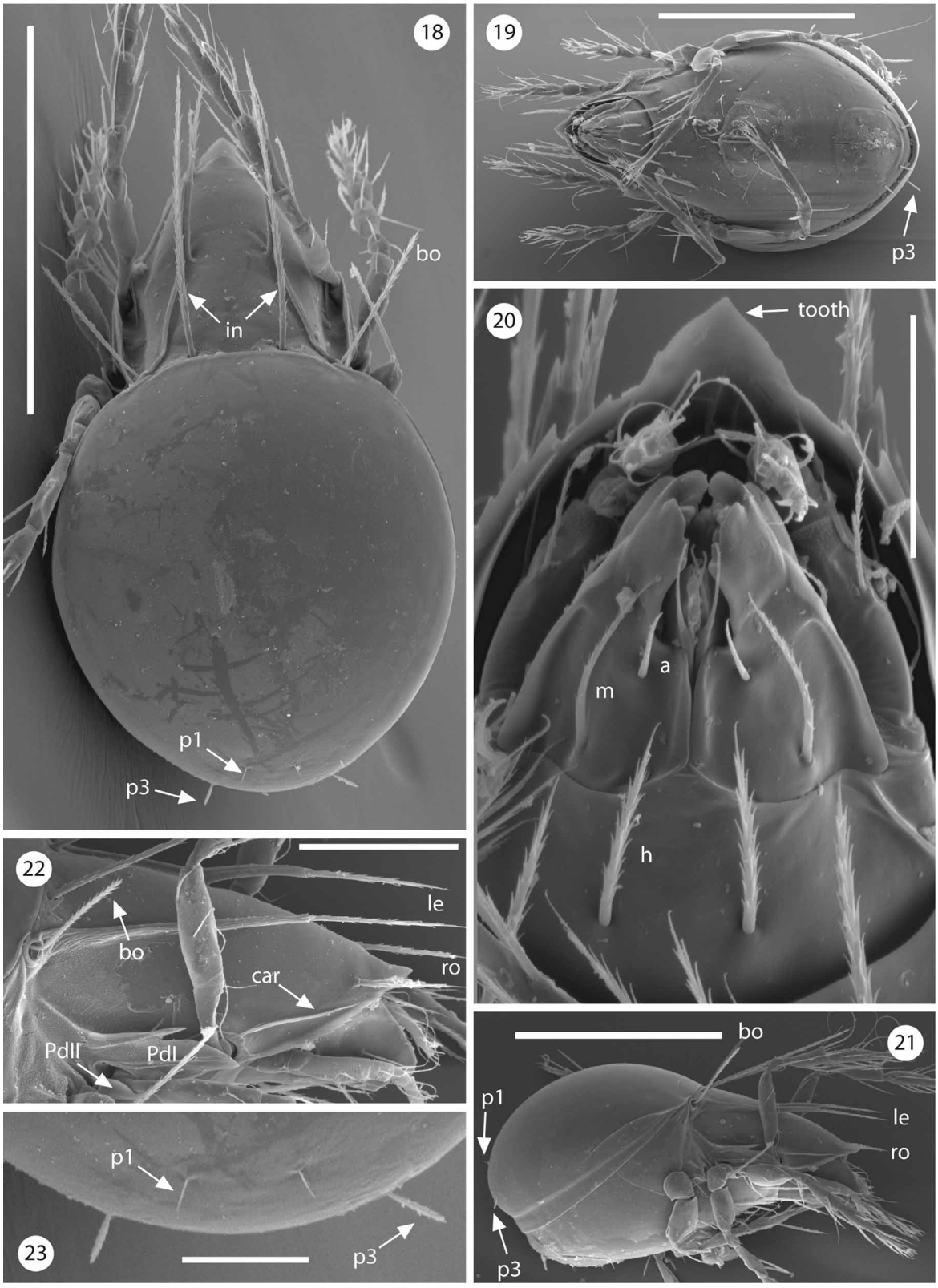
Material examined. Holotype: Adult female. Canada, British Columbia, Vancouver Island, Sydney Inlet, Clayoquot Sound (49°30'N, 126°17'W), 12 August 2007 (K. Jordan & Z. Lindo) from moss in canopy of Sitka spruce (*Picea sitchensis* (Bong.) Carr.); deposited in the CNC, type No. 23977. Paratypes: two with same data as holotype. Canada, British Columbia, Vancouver Island: Moyeha Watershed, Clayoquot Sound (49º24'N, 125º54'W), 14 August 2007 (K. Jordan), two from moss in canopy of Sitka spruce; Watta Watershed, Clayoquot Sound (49º27'N, 126º01'W), 15 August 2007 (K. Jordan), two from moss in canopy of Sitka spruce; Tranquil Watershed, Clayoquot Sound (49º12'N, 125º40'W), 18 August 2007 (K. Jordan), two from moss in canopy of Sitka spruce.

USA, Oregon, Curry County: Sunshine Bar, Rogue River National Forest (42°42'N, 124°19'W), 12 July 1985 (I.M. Smith), three from moss on rocks; Alfred A. Loeb State Park (42°6'N, 124°11'W), 12 August 1985 (E.E. Lindquist), three from moss and lichens around trunks of tan-oak and willow. Paratypes deposited in the CNC, PFC, and ZLC.

Other material examined. Canada, British Columbia, Vancouver Island, Upper Walbran Valley (48°39'N, 124°35'W). USA, Washington, Quinault Rain Forest, Olympic National Forest (47°32'N, 123°40'W). Oregon, Oneonta Gorge, Mt. Hood National Forest (45°35'N, 122°4'W); Proxy Falls, Willamette National Forest (44°9'N, 121°55'W).



FIGURES 16–17. *Ceratoppia tofinoensis* **n. sp.**, adult female. **16**, Dorsal aspect; **17**, Ventral aspect. Legs removed. Scale bars = 300 µm.



FIGURES 18–23. *Ceratoppia tofinoensis* **n. sp.**, scanning electron microscope images of adult. **18**, habitus, dorsal aspect, interlamellar setae (*in*), bothridial setae (*bo*), posterior setae (p_1, p_3); **19**, habitus, ventral aspect, posterior setae (p_3); **20**, gnathosoma, ventral aspect, gnathosomal setae (*a*, *m*), hypostomal setae (*h*), and rostral tooth ; **21**, habitus, lateral aspect, bothridial setae (*bo*), lamellar setae (*le*), rostral setae (*ro*), and posterior setae (p_1, p_3); **22**, prodorsum, lateral aspect, bothridial setae (*bo*), lamellar setae (*le*), rostral setae (*ro*), lateral carina (car), pedotectum I (PdI), and pedotectum II (PdII); **23**, posterior notogaster, dorsal aspect, posterior notogastral setae (p_1, p_3). Scale bars = 300 µm (Figs. 18, 19, 21), 100 µm (Fig. 22), and 50 µm (Figs. 20, 23).

Etymology. The specific epithet refers to the town of Tofino within the Clayoquot Sound UNESCO Biosphere Reserve on Vancouver Island, Canada, the type locality of this species.

Diagnosis. Adult. Total length 530–580 µm, with character states of Peloppiidae (Grandjean, 1954; as Ceratoppiidae), and character states of *Ceratoppia* as described above. This species can be differentiated from other *Ceratoppia* by the presence of two pairs of very short posterior setae (p_1, p_3); single pair of hypostomal setae on mentum; interlamellar setae longer than lamellar cusps; lamellae not reaching the insertion of the rostral setae; wide medial rostral tooth.

Description. Adult. (Figs. 16–23)

Measurements: Mean total length: females (n = 3) 573 µm (range 570–580); males (n = 1) 530 µm (Figs. 16–17). Mean notogastral width: females (n = 3) 333 µm (range 320–380); males (n = 1) 310 µm.

Integument: Smooth to microtuberculate; cerotegument primarily present at dorsosejugal scissure and laterally on prodorsum. **Prodorsum:** Rostrum with wide medial tooth (Fig. 20), and about three lateral denticles. Seta *ro* 65–75 µm long, acuminate, heavily barbed, extending well beyond rostrum (Fig. 16, Figs. 21–22). Lamellae about 192 µm long to end of cusps, not reaching insertion of *ro*. Lamellar cusps about 70 µm long with short lateral denticle. Seta *le* about 97 µm long, thick, heavily barbed, tapering to a sharp point (Figs. 21–22). Seta *in* thick, heavily barbed, 216 µm long, extending anteriorly to or just beyond tips of lamellae (Fig. 16, Fig. 18). Mutual distance of setal pairs *ro–ro*, *le–le*, and *in–in*, about 46, 58, and 66 µm, respectively. Seta *ex* not observed; alveoli lateral of bothridial cups. Bothridial seta 135 µm long, with long barbs, almost brush–like (Fig. 18). **Lateral aspect of prodorsum:** Pedotectum I well developed, dentate anteriorly, with dorsal cusp, about 20 µm, triangular in shape (Fig. 22). Pedotectum II well developed, rounded anteriorly. **Notogaster:** Longer than wide, (ratio l:w = 1.11:1); hysterosoma often fattened with two to four eggs of considerable size (about 264 µm long). Notogastral setae reduced to alveoli, except for two pairs of posterior setae (Fig. 18, Fig. 23). Alveoli with porose areas (Fig. 16). Minute depressions of notogaster in position of h_1. Posterior notogastral setae p_1, about 13 µm long (range 10–20, n = 11), thin, setose or with minute barbs; setae p_3 about 27 µm long (range 20–30, n = 11) barbed, thicker than p_1 (Fig. 23). Single specimen with asymmetical hypertricous p_3 seta on right side. Lyrifissures *im*, *ip*, *ih*, and *ips* present, all about 10 µm long; *im* anteriomedial to notogastral alveoli *lp*. **Ventral region:** Apodeme IV forming shallow furrow with minitectum on anterior portion, thinning near genital aperture as described by Grandjean (1970). Coxisternal setae barbed, acuminate, relatively long; formula (epimeres I to IV) 3–1–3–3. Setae lengths as follows: *1a*, *1b*, *1c* about 33, 71, 68 µm, respectively, *2a*, *3a*, *3b*, *3c* about 32, 26, 74, 24 µm, respectively, and *4a*, *4b*, *4c* about 30, 29 and 24 µm, respectively. Extra *2a* setae on right side of single specimen (Fig. 17). Six pairs of genital setae ranging in length from 18–23 µm, with longest g_5 and g_6, setose. Aggenital seta about 21 µm long, setose, asymmetry observed in a single specimen (two pairs of aggenital setae on left side). Two pairs of anal setae about 13 µm long. Three pairs of adanal setae; ad_3 20 µm, thin, barbed, different from ad_1 and ad_2 which are barbed, thicker, about 29 and 27 µm long, respectively, subequal to p_3 (Fig. 17, Fig. 19). Lyrifissure *iad* 8 µm long, anteriolateral to ad_3. **Gnathosoma:** Subcapitular mentum without tectum; one pair of setae *h* about 53 µm long; gnathosomal setae *m* 44 µm long; *a* about 28 µm long (Fig. 20).

Legs: Ratio of leg IV to body length about 0.7:1. Approximate lengths of leg segments (femur, genu, tibia, tarsus; in µm): I 135, 38, 73, 141; II 97, 24, 66, 118; III 64, 35, 84, 124; IV 72, 57, 112, 162. Pretarsus tridactylous with large smooth empodial and slightly thinner lateral claws. Setation (I–IV, number of solenidia in parentheses): trochanters 1–1–2–1; femora 5–4–3–2; genua 3(1)–3(1)–2(1)–3; tibiae 4(2)–4(1)–3(1)–3(1); tarsi 20(2)–15(2)–15–12; setation indicated in Table 2. Femur of leg II–IV with well developed ventral keel; femur leg I relatively slender without ventral keel. Seta *d* absent from genua and tibiae of leg I, no evidence of retention associated with socket of solenidion φ_1, as illustrated for *Ceratoppia bipilis* (Grandjean 1935). Tibiae solenidion φ_1 of leg I flagellate, well anterior of φ_2. Leg I tarsal solenidia ω_1 and ω_2 flagellate; famulus *e* tiny, spinose. Leg II tarsal solenidia ω_1 and ω_2 subequal, straight. Leg IV seta *l'* of tibia and tarsus large, heavily barbed, almost 100 µm long. Single specimen with deformed right leg I tibia and tarsus; tibia slightly reduced in size and missing *v'*; tarsus greatly reduced in size (approximately half the length), without claws, ending in a blunt curve, setae greatly reduced in size, some phylloform.

Remarks. *Ceratoppia tofinoensis* **n. sp.** is differentiated from other species of *Ceratoppia* by a unique set of character states rather than a single diagnostic character: two pairs of short posterior setae (p_1, p_3); single pair of hypostomal setae on mentum; interlamellar setae longer than lamellar cusps; lamellae not reaching the insertion of

the rostral setae; medial rostral tooth. Patterns of posterior setal expression for *C. tofinoensis* **n. sp.** follow the dominant character state of two pairs of posterior seta (p_1 and p_3) expressed (Seniczak & Seniczak 2010), although the reduction of h_1 alveoli to small depressions suggests a variability in h_1, p_1 setae expression in other species may be more complicated than previously considered.

Distribution.: *Ceratoppia tofinoensis* **n. sp.** appears to have a restricted distribution within the coastal temperate rainforest of the North American Pacific Northwest, possibly due to low sampling in arboreal habitats, or general low abundance compared to *C. indentata* and *C. longicupsis*. Within Canada, *C. tofinoensis* appears restricted to west coastal locations on Vancouver Island, occurring with highest densities within Clayoquot Sound UNESCO Biosphere reserve near the town of Tofino, British Columbia. Southern records of *C. tofinoensis* through Washington and Oregon States are for single specimens, but include more continental locations such as Mt. Hood National Forest, Oregon and the Willamette National Forest, Oregon. *Ceratoppia tofinoensis* may be an arboreal specialist, which would reduce the incidence of collection in most sampling, and explain the low occurrence in the rest of *C. tofinoensis* range.

Ceratoppia valerieae n. sp.

Material examined. Holotype: Adult female. Canada, British Columbia, Vancouver Island, Upper Walbran Valley (48°39'N, 124°35'W), 25 July 2005 (Z. Lindo) from suspended soil and bark scraping at 30 m in western redcedar (*Thuja plicata* D. Don); deposited in the CNC, type No. 23978. Paratypes: 15 with same data as holotype. Canada, British Columbia: Vancouver Island, Cowichan Lake Field Station (48°50'N, 124°10'W), 16 June 1979 (I.M. Smith), four from leaf litter beside creek; Spruce Bay Beach, E.C. Manning Provincial Park (49°3'N, 120°50'W), 13 July 1986 (V. Behan-Pelletier), six from decaying moss on trunk under western redcedar. USA, Washington, Spruce Trail, Olympic National Park (47°51'N, 123°56'W), 25 September 2000 (V. Behan-Pelletier), three from twigs of western hemlock. Paratypes deposited in the CNC, RNC, and ZLC.

Other material examined. Canada, British Columbia, Vancouver Island: Upper Carmanah Valley (48°44'N, 124°37'W); Barkley Sound (48°58'N, 124°6'W); Caycuse (48°53'N, 124°21'W); Mesachie Lake (48°48'N, 124°7'W); Honeymoon Bay (48°48'N, 124°10'W); Municipality of the Highlands (48°32'N, 123°30'W); British Columbia: Graham Island, Haida Gwaii (53°28'N, 132°25'W); Tweedsmuir South Provincial Park (53°3'N, 126°21'W); Garibaldi Provincial Park (49°53'N, 122°47'W); Manning Park, E.C. Manning Provincial Park (49°10'N, 119°33'W); Oliver (49°3'N, 120°46'W); Madeline Lake, Penticton (49°30'N, 119°38'W); Lumby (50°15'N, 118°58'W); Sugar Lake (50°24'N, 118°29'W); Silverton (49°55'N, 117°22'W). Alberta, Waterton Lakes National Park (49°8'N, 113°58'W). USA, Washington, Nason Creek, Wenatchee National Forest (47°47'N, 120°42'W); Wind River Canopy Crane, Gifford Pinchot National Forest (45°48'N, 121°55'W); Grand Ronde River at Hwy 129 (46°2'N, 117°15'W). Oregon, Proxy Falls, Willamette National Forest (44°9'N, 121°55'W). California, Mendocino National Forest (39°34'N, 122°49'W); Stirling City (39°53'N, 121°31'W); Purisima Creek Redwoods Regional Open Space near Halfmoon Bay (37°24'N, 122°21'W).

Etymology. This species is named in honour of the eminent oribatologist Dr. Valerie Behan–Pelletier, mentor and friend, who has contributed extensively to our knowledge of oribatid mites.

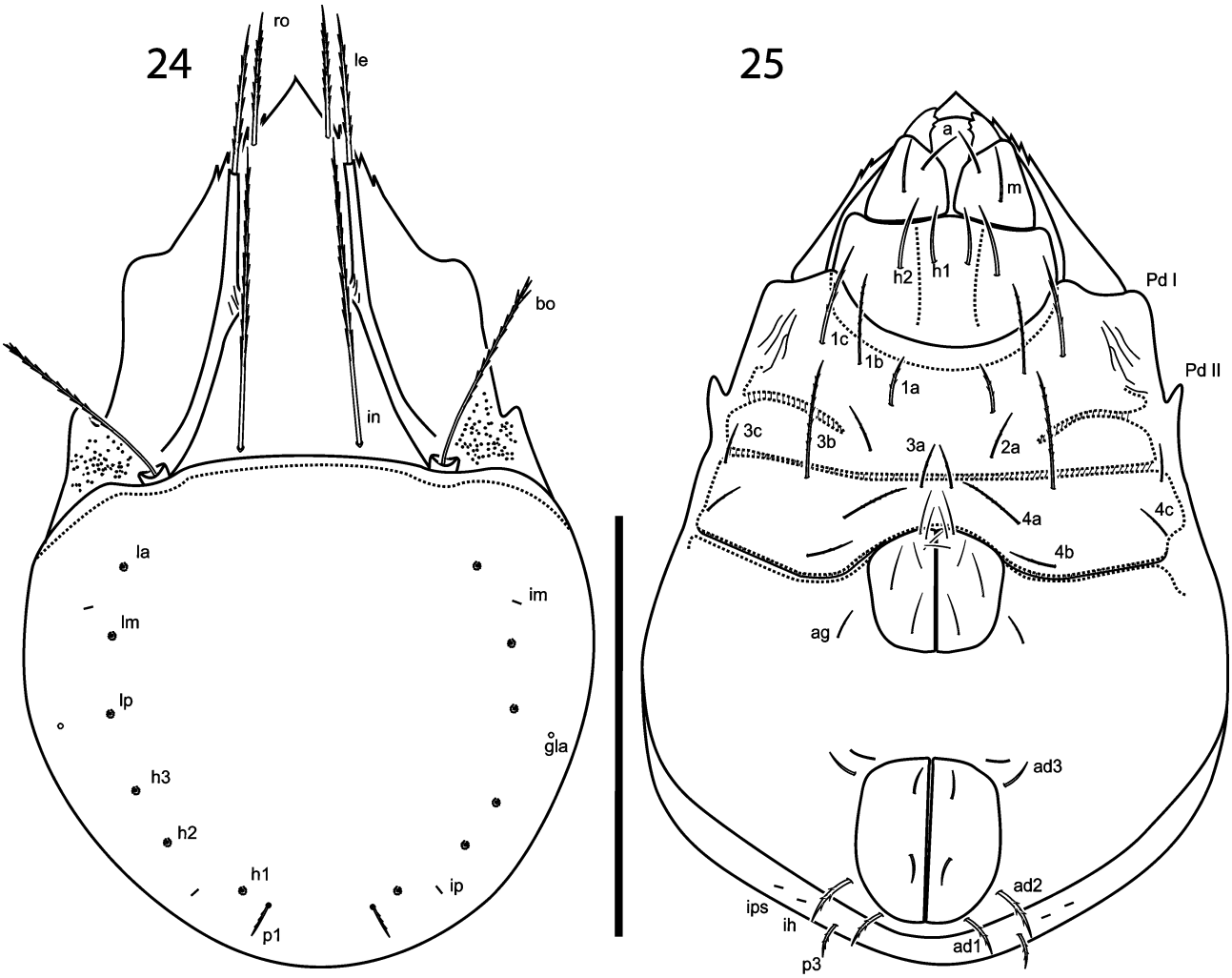
Diagnosis. Adult. Total length 540–670 µm, with character states of Peloppiidae (Grandjean 1954; as Ceratoppiidae), and character states of *Ceratoppia* as described above. This species can be differentiated from other *Ceratoppia* by the presence of two pairs of hypostomal setae on mentum; two pairs of very short posterior notogastral setae (p_1, p_3), lamellae not reaching insertion of rostral setae; wide medial rostral tooth.

Description. Adult. (Figs. 24–31)

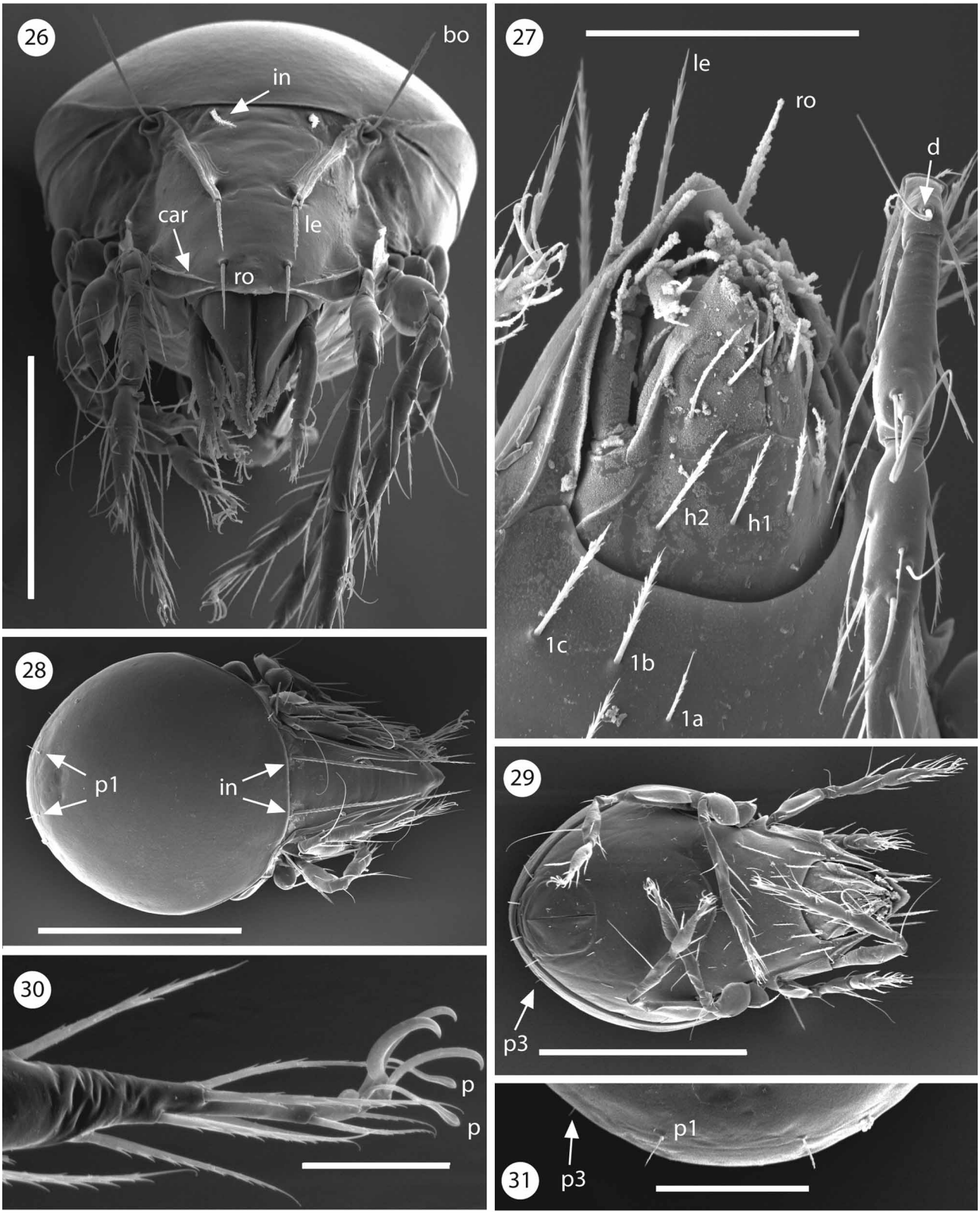
Measurements: Mean total length: females (n = 6) 647 µm (range 590–670); males (n = 4) 585 µm (range 540–650) (Figs. 24–25, Fig. 28). Mean notogastral width: females (n = 6) 388 µm (range 370–410); males (n = 4) 348 µm (range 300–390).

Integument: Microtuberculate. Integument laterad of bothridial setae between acetabula III and IV tuberculate. Cerotegument microtuberculate, primarily present at dorsosejugal scissure and laterally on prodorsum. **Prodorsum:** Rostrum coming to a point with about five lateral teeth. Lateral ridge extending from base of acetabula I to rostrum (Fig. 26). Seta *ro* 43–58 µm long, barbed, tapering, extending well beyond rostrum (Figs. 26–27). Lamellae about 200 µm long to end of cusps, not reaching insertion of *ro*. Lamellar cusps about 73 µm long with

small lateral denticle. Seta *le* about 93 µm long, barbed, tapering, extending anteriorly beyond rostrum (Figs. 26–27). Seta *in* barbed, 206 µm long, extending anteriorly to reach, or just beyond end of lamellae (Fig. 28). Mutual distance of setal pairs *ro–ro*, *le–le*, and *in–in*, about 51, 64, and 77 µm, respectively. Seta *ex* not observed; alveoli lateral of bothridia. Bothridial seta 126 µm long, barbed, with barbs increasing in length terminally (Fig. 26). **Lateral aspect of prodorsum:** Pedotectum I well developed, dentate anteriorly, with dorsal cusp about 15 µm. **Notogaster:** Slightly longer than wide, (ratio l:w = 1.07:1); hysterosoma often fattened with one to eight eggs (about 255 µm long). Notogastral setae reduced to alveoli, except for two pairs of posterior setae (Fig. 31). Posterior notogastral setae p_1, about 22 µm long (range 18–30, n = 13), thin, barbed; setae p_3 about 15 µm long (range 13–23, n = 13) thin, barbed (Fig. 31). Lyrifissures *im*, *ip*, *ih*, and *ips* present, all about 8 µm long. **Ventral region:** Coxisternal setae barbed, acuminate, relatively long; formula (epimeres I to IV) 3–1–3–3. Setae lengths as follows: *1a*, *1b*, *1c* about 34, 62, 67 µm, respectively (Fig. 27); *2a*, *3a*, *3b*, *3c* about 33, 27, 76, 25 µm, respectively, and *4a*, *4b*, *4c* about 38, 31 and 29 µm, respectively (Fig. 25). Six pairs of genital setae ranging in length from 20–38 µm, with longest g_5 and g_6, setose. Aggenital seta about 20 µm long, setose. Two pairs of anal setae about 16 µm long, setose. Asymmetry observed in single specimen with extra anal setae on left side. Three pairs of adanal setae; ad_3 about 24 µm, thin, barbed; ad_1 and ad_2 thicker, barbed, about 28 and 29 µm long, respectively (Fig. 25). Lyrifissure *iad* 10 µm long, anterior to ad_3. **Gnathosoma:** Subcapitular mentum without tectum; two pairs of hypostomal setae, h_1 (medial) about 46, h_2 (lateral) about 48 µm long (Fig. 25, Fig. 27). Asymmetry observed in three specimens, two which had reduced number of *h* setae on left side, and one which possessed an extra *h* setae (3) on right side. Gnathosomal setae *m* 44 µm long, and *a* about 29 µm long.



FIGURES 24–25. *Ceratoppia valerieae* **n. sp.**, adult female. **24**, dorsal aspect; **25**, ventral aspect. Legs removed. Scale bars = 300 µm.



FIGURES 26–31. *Ceratoppia valerieae* **n. sp.**, scanning electron microscope images of adult. **26**, habitus, frontal aspect, bothridial setae (*bo*), interlamellar setae (*in*), lamellar seta (*le*); rostral setae (*ro*), lateral carina (car); **27**, gnathostome, ventral aspect, lamellar setae (*le*), rostral setae (*ro*), two pairs of hypostomal setae (h_1, h_2), epimeral setae *1a*, *1b*, and *1c*, genua leg I seta *d* stub (*d*); **28**, habitus, dorsal aspect, posterior setae (p_1), interlamellar setae (*in*); **29**, habitus, ventral aspect, posterior setae (p_3); **30**, distal portion of tarsus leg IV, setae *p'* and *p"*; **31**, posterior notogaster, dorsal aspect, posterior setae (p_1, p_3). Scale bars = 300 µm (Figs. 28, 29), 200 µm (Fig. 26), 100 µm (Figs. 27, 31), and 30 µm (Fig. 30).

Legs: Ratio of leg IV to body length about 0.7:1. Approximate lengths of leg segments (femur, genu, tibia, tarsus; in µm): I 139, 37, 86, 142; II 109, 27, 80, 133; III 75, 37, 107, 135; IV 73, 35, 94, 117. Pretarsus tridactylous with large smooth empodial and slightly thinner lateral claws. Setation (I–IV, number of solenidia in parentheses): trochanters 1–1–2–1; femora 5–4–3–2; genua 4(1)–3(1)–2(1)–3; tibiae 4(2)–4(1)–3(1)–3(1); tarsi 20(2)–15(2)–15–12; setation indicated in Table 2. Seta *d* retained as a small stub on genua leg I (Fig. 27). Leg I tibia solenidion φ_1 on prominent tubercle, retention of seta *d* associated with socket of solenidion φ_1 in some specimens, as illustrated for *Ceratoppia bipilis* (Grandjean 1935). Setae *p'* and *p"* of leg I tarsus, straight, not barbed; setae *p'* and *p"* of tarsus legs II–IV ending in bulbous tip (Fig. 30). Tibiae solenidion φ_2 of leg I only ¼ length of φ_1; leg I tarsal solenidia ω_1 and ω_2 subequal, straight. Leg I tarsal seta *s* horn-like. Porose areas dorsolateral and antiaxial on femora of all legs, and trochanters III, IV. Femora with crenulations.

Remarks. The dominant gnathosomal setae character state is a single pair of hypostomal setae (*h*) on the mentum as reported for most described species. However, *C. clavisensillata* Choi, 1998, *C. bipilis*, and the subspecies *C. bipilis spinipes* possess two pairs of hypostomal setae. *Ceratoppia valerieae* **n. sp.** also possess two pairs of hypostomal setae, but differs from *C. bipilis* and *C. bipilis spinipes* in having very short posterior notogastral setae, and from *C. clavisensillata* in having setiform bothridial setae with barbs, rather than clavate bothridial setae (Choi 1998). There are two possibly undescribed species of *Ceratoppia* from eastern Canada which also possess two pairs of *h* setae, and further investigation into these, and differences between *C. bipilis* and *C. bipilis spinipes* are warranted. Hypertrichy / neotrichy in the form of two pairs of hypostomal setae is rare among Oribatida, and when present in *Ceratoppia*, arises in the tritonymph (Grandjean 1936). Grandjean (1936) also noted that asymmetry in hypostomal setae was common among species possessing two pairs of as seen here.

Distribution. *Ceratoppia valerieae* **n. sp.** occurs frequently throughout southern Vancouver Island, British Columbia, Canada. In forest floor samples, it occurs in low abundance, however it was the dominant microarthropod collected in canopy malaise traps in the Upper Carmanah Valley. Distribution range of *C. valerieae* follows a north–south coastal temperate rainforest distribution, however, also occurs in interior zones of British Columbia and Washington. *Ceratoppia valerieae* is the dominant *Ceratoppia* of interior British Columbia occurring as far east as Waterton Lakes National Park, Alberta where it frequently co–occurs with *C. bipilis*. Interior populations of *C. valerieae* are a bit larger, with slightly longer prodorsal and posterior notogastral setae, however, relative proportions of setae to body size are the same. Specimens collected from northern populations (Haida Gwaii and Tweedsmuir Provincial Park near Bella Coola, British Columbia) are larger and darker than specimens collected from other locations in British Columbia. Similarly, the specimens observed from the most southerly part of the distribution (Proxy Falls, Oregon, and Stirling City and Half Moon Bay, California) exhibited morphological variation in the form of a larger body size.

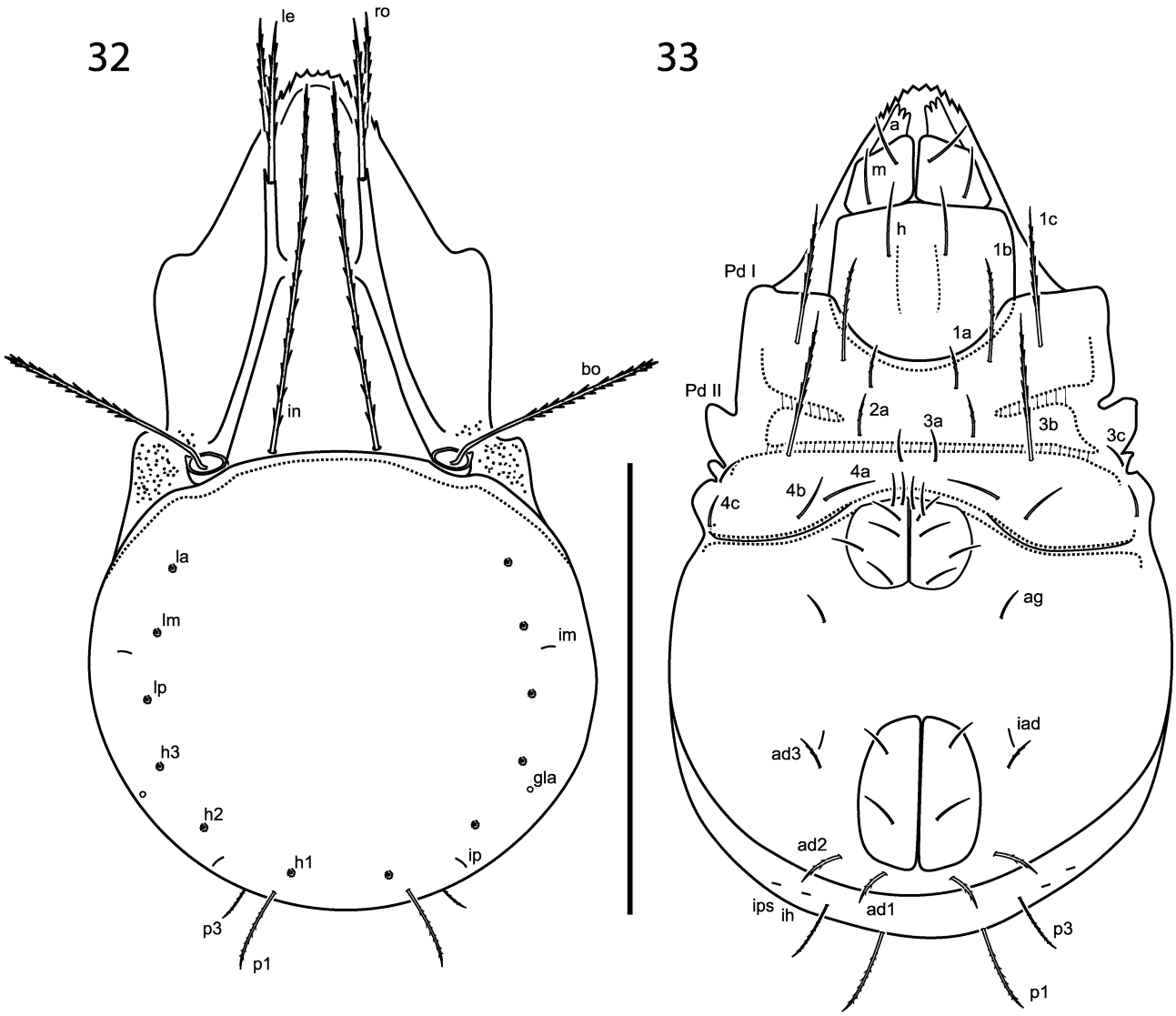
Ceratoppia offarostrata n. sp.

Material examined. Holotype: Adult female. Canada, British Columbia, Vancouver Island, Upper Walbran Valley, 48°39'N, 124°35'W, 25 July 2005 (Z. Lindo & N.N. Winchester) from bark scraping at 16 m in western redcedar (*Thuja plicata* D. Don); deposited in the CNC, type No. 23976. Paratypes: 20 with same data as holotype. Canada, British Columbia, Vancouver Island, Pacific Rim National Park Reserve, Rainforest Trail (49°00'N, 125°37'W), 13 October 2005 (V. Behan-Pelletier), one from moss and bark at breast height on western redcedar. Paratypes deposited in the CNC, PFC, RNC, and ZLC.

Other material examined. Canada, British Columbia: Graham Island, Haida Gwaii (53°28'N, 132°25'W); Cape St. James, Gwaii Haanas National Park Reserve, Haida Gwaii (51°56'N, 131°1'W).

Etymology. The specific epithet is from the Latin "*offa*" meaning "lump", and refers to the prominent bump on the rostrum seen in lateral view.

Diagnosis. Adult. Total length 570–640 µm, with character states of Peloppiidae (Grandjean, 1954; as Ceratoppiidae), and character states of *Ceratoppia* as described above. This species can be differentiated from other *Ceratoppia* by the presence of a single pair of hypostomal setae; two pairs of posterior notogastral setae conspicuous (p_1, p_3); rostrum rounded with many denticles but without prominent medial tooth, or indentation; rostrum in lateral view with prominent 'bump'; lamellae with short cusps not reaching the insertion of rostral setae; interlamellar setae distinctly longer than lamellae.

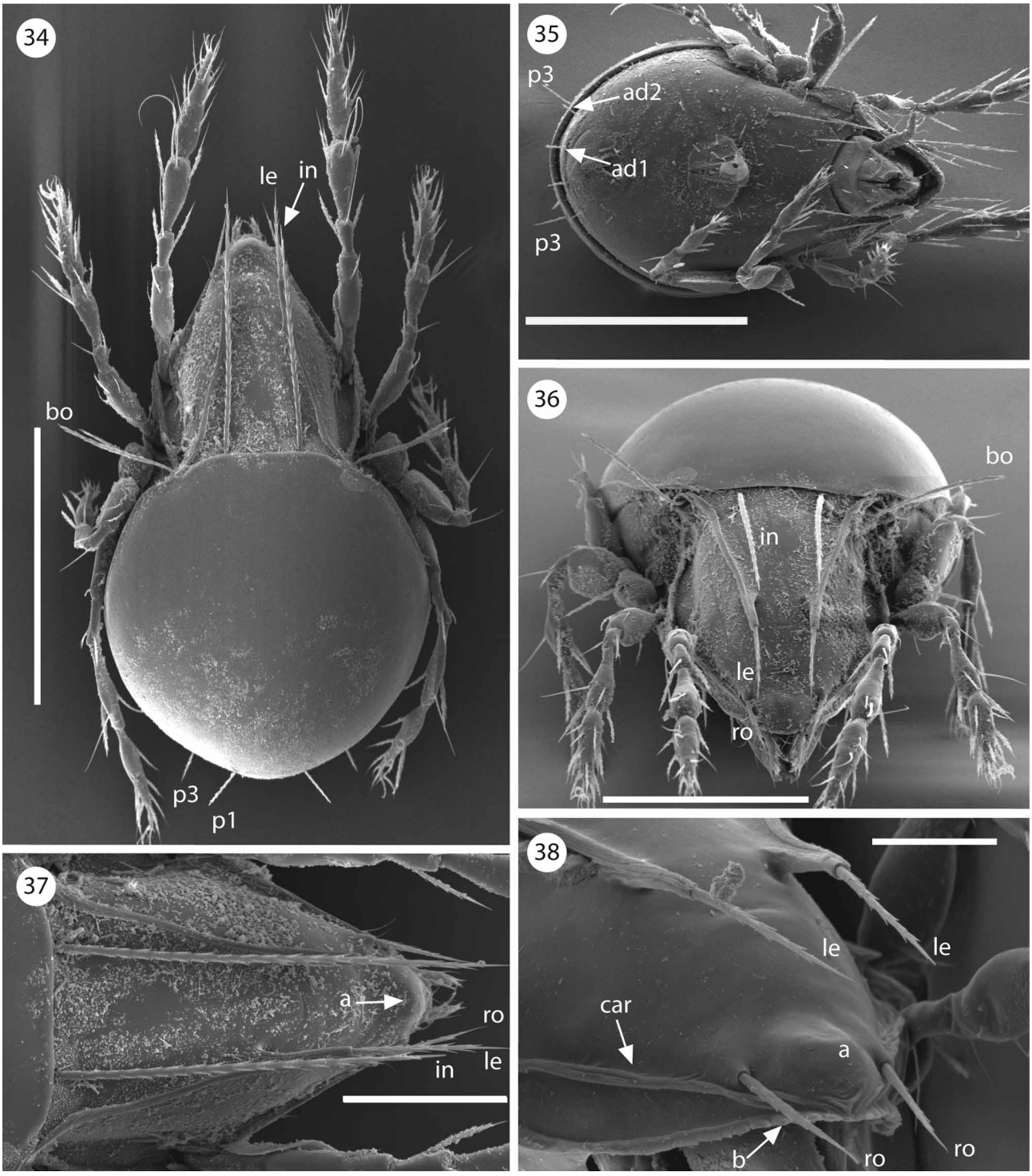


FIGURES 32–33. *Ceratoppia offarostrata* **n. sp.**, adult female. **32**, dorsal aspect; **33**, ventral aspect. Legs removed. Scale bars = 300 µm.

Description. Adult. (Figs. 32–38)

Measurements: Mean total length: females (n = 6) 625 µm (range 620–640); males (n = 4) 575 µm (range 570–580) (Figs. 32–34). Mean notogastral width: females (n = 6) 360 µm (range 330–370); males (n = 4) 333 µm (range 310–350).

Integument: Smooth to microtuberculate. Integument laterad of bothridial setae between acetabula III and IV tuberculate. **Prodorsum:** Rostrum without medial tooth, dentate with five to eight teeth (Fig. 32, Figs. 37–38). Seta *ro* 80 µm long, acuminate, thick, barbed, extending well beyond rostrum (Figs. 36–38). Lamellae about 220 µm long to end of cusps, not reaching insertion of *ro* (Fig. 37). Lamellar cusps about 61 µm long. Seta *le* about 110 µm long, barbed, tapering, extending anteriorly well beyond rostrum (Figs. 36–38). Seta *in* barbed, 260 µm long, extending anteriorly beyond tips of lamellae (Fig. 37). Mutual distance of setal pairs *ro–ro*, *le–le*, and *in–in*, about 68, 60, and 77 µm, respectively. Seta *ex* not observed; alveoli removed anteriolaterally from bothridial. Bothridial seta 160 µm long, with long barbs (Fig. 34). **Lateral aspect of prodorsum:** Pedotectum I well developed, rounded and crenulate anteriorly, with dorsal cusp about 18 µm long. Prominent bump on the rostrum seen in lateral view (Figs. 37–38). Lateral ridge from base of acetabula I to base of rostrum (Fig. 38). **Notogaster:** Subequal length to width, (ratio l:w = 1.01:1); hysterosoma often fattened with four eggs of considerable size (about 280 µm long). Notogastral setae reduced to alveoli, except for two pairs of posterior setae. Posterior notogastral setae p_1 about 55 µm long (range 48–63, n = 11), barbed; setae p_3 about 46 µm long (range 40–55, n = 10) barbed (Fig. 32, Fig. 34).



FIGURES 34–38. *Ceratoppia offarostrata* **n. sp.**, scanning electron microscope images of adult. **34**, habitus, dorsal aspect, bothridial setae (*bo*), interlamellar setae (*in*), lamellar seta (*le*), posterior setae (p_1, p_3); **35**, habitus, ventral aspect, posterior setae (p_3), adanal setae (ad_1, ad_2); **36**, habitus, frontal aspect, bothridial setae (*bo*), interlamellar setae (*in*), lamellar seta (*le*), rostral setae (*ro*); **37**, prodorsum, dorsal aspect, interlamellar setae (*in*), lamellar setae (*le*), rostral setae (*ro*), and rostral bump (a); **38**, rostrum, anterio–lateral aspect, showing rostral bump (a), rostral setae (*ro*), lamellar setae (*le*), and lateral carina (ca). Scale bars = 300 µm (Fig. 34, 35), 200 µm (Fig. 36), 100 µm (Fig. 37), and 50 µm (Fig. 38).

Lyrifissures *im*, *ip*, *ih*, and *ips* present, all about 8 µm long. **Ventral region:** Coxisternal setae smooth or with a few barbs, acuminate; formula (epimeres I to IV) 3–1–3–3 (Fig. 33). Setae lengths as follows: *1a*, *1b*, *1c* about 35, 78, 93 µm, respectively, *2a*, *3a*, *3b*, *3c* about 32, 21, 94, 21 µm, respectively, and *4a*, *4b*, *4c* about 37, 35 and 21 µm,

respectively. Six pairs of genital setae ranging in length from 18–25 µm, with longest g_5 and g_6, setose. Aggenital seta about 21 µm long, setose, acuminate. Two pairs of anal setae about 21 µm long, acuminate. Three pairs of adanal setae; ad_3 24 µm, ad_1 34 µm and ad_2 30 µm, all barbed (Fig. 33, Fig. 35). Lyrifissure *iad* 8 µm long, anterior to ad_3. **Gnathosoma:** Subcapitular mentum without tectum; one pair of *h* setae about 52 µm long; gnathosomal setae *m* 38 µm long, and *a* about 31 µm long.

Legs: Ratio of leg IV to body length about 0.65:1. Approximate lengths of leg segments (femur, genu, tibia, tarsus; in µm): I 143, 35, 93, 134; II 111, 27, 79, 114; III 73, 35, 94, 117; IV 75, 50, 107, 150. Pretarsus tridactylous with large smooth empodial and slightly thinner lateral claws. Setation (I–IV, number of solenidia in parentheses): trochanters 1–1–2–1; femora 5–4–3–2; genua 3(1)–3(1)–2(1)–3; tibiae 4(2)–4(1)–3(1)–3(1); tarsi 20(2)–15(2)–15–12; setation indicated in Table 2. Seta *d* absent from genua and tibiae of adult, no evidence of retention associated with socket of solenidion φ_1. Most of leg setae conspicuously barbed. Seta *ft"* on tarsus leg IV prominent, thick, barbed. Femur of leg III–IV with well developed ventral keel; femur leg I–II relatively slender without ventral keel, with bumpy cerategument anteriorly. Tibiae solenidion φ_1 of leg I flagellate, anterior of φ_2 which is straight, sharp. Leg II tarsal solenidia ω_1 and ω_2 subequal, straight, relatively short; tibial solenidia φ straight, twice as long as genua solenidia σ. Porose areas dorsolateral and antiaxial on femora of all legs, and trochanters III, IV. Single specimen with deformed right leg I tarsus.

Remarks. *Ceratoppia offarostrata* **n. sp.** and *C. sexpilosa* share the characteristic rostral 'bump', but *C. offarostrata* differs from *C. sexpilosa* in the number and expression of posterior notogastral setae. *Ceratoppia offarostrata* has two pairs of posterior notogastral setae (p_1 and p_3 expressed) versus three pairs (h_1, p_2, p_3 expressed) in *C. sexpilosa* (Hammer 1967). *Ceratoppia offarostrata* also lacks a prominent medial rostral tooth; other similar species which lack medial rostral tooth include *C. sphaerica* and *C. hoeli* Thor, 1930, but these lack the rostral 'bump'. *Ceratoppia hoeli* also differs from *C. offarostrata* in having simple posterior seta, very short lamellar cusps, and long lamellar setae (Thor 1930). *Ceratoppia sphaerica* is quite similar to *C. offarostrata* (two pairs of medium sized, barbed p_1, p_3 setae) but in addition to lacking the rostral bump, *C. sphaerica* is much larger in size (0.7–1.0 mm) (Hammer 1955; Seniczak & Seniczak 2010). A full diagnosis and comparison of *C. offarostrata* with *C. sphaerica* is problematic though as the original type specimen of *C. sphaerica* as described by L. Koch (1879) is unknown; the original drawings and text are poor. The consensus of character states for *C. sphaerica* are: large body size (700–1000 um); dark (almost black) in colour; prodorsum rounded anteriorly with a serrate or dentate edge; lamellar setae longer than rostral setae; interlamellar setae as long as prodorsum, longer than lamellae; lamellae not reaching insertion of rostral setae, with short cusps; two pair, rather short posterior notogastral setae (p_1 and p_3) (Trägårdh 1906; Gilyarov 1975; Hammer 1952; 1955; Seniczak & Seniczak 2010).

Distribution. *Ceratoppia offarostrata* **n. sp.** occurs in low frequency and low abundance in samples collected from the Walbran Valley on Vancouver Island, British Columbia. Specimens collected from type locality in Walbran Valley are associated exclusively with bark scraping samples on western redcedar. Similarly, specimens collected from Pacific Rim National Park, British Columbia are from moss and bark samples collected from western redcedar trees at breast height. Association with bark habitats, and the possibility of host tree specificity, may explain the low occurrence of collection for this species. The distribution range of *C. offarostrata* appears limited to coastal locations on Vancouver Island and Haida Gwaii. Specimens collected from Haida Gwaii have slightly shorter posterior setae and reduced rostral bump. The distributional patterns of *C. sphaerica* suggest this species is limited to arctic and subarctic areas in western Canada; *C. offarostrata* may be southern variant subspecies of *C. sphaerica*; further sampling of *C. offarostrata* and comparison with *C. sphaerica* is warranted.

Genetic analysis

Ten specimens of *Ceratoppia* were successfully sequenced for the cytochrome *c* oxidase I (COI) gene (>200 base pair) at the Biodiversity Institute of Ontario for inclusion with the Barcode of Life (BOLD) Systems (Ratnasingham & Hubert 2007). Primers, PCR and sequencing follow the methods of Ivanova *et al.* (2006), and all sequences are available from BOLD Systems (http://www.barcodinglife.org). Successfully sequenced individuals confirm the status of *C. indentata* (four indiv.), *C. longicuspis* (three indiv.), *C. valerieae* (two indiv.), and *C. offarostrata* (one indiv.) as genetically unique species. While specimens of *C. tofinoensis* were sent for analysis, no usable sequences were generated.

Discussion

The two main character states differentiating North American species of *Ceratoppia* are the number of hypostomal setae on the subcapitular mentum, and the number, length and expression of posterior notogastral setae. The dominant character state for hypostomal setae among the *Ceratoppia* is one pair of setae, although *C. bipilis*, *C. bipilis spinipes*, *C. clavisensilla*, and *C. valerieae* have two pairs of *h* setae, as well as another undescribed species observed from eastern Canada (pers. obs.). Grandjean (1936) considered two pairs of hypostomal setae to be a derived character, rare among the Oribatida, arising in the tritonymphal stage in the genus *Ceratoppia*. This character appears conserved within species, however setal asymmetry, including among the hypostomal setae is not uncommon, as also noted by Grandjean (1936). In the specimens observed here, setal asymmetry (hypertrichy and hypotrichy) was observed in hypostomal setae among *C. valerieae*.

Variations in setal expression and hypertrichy were also observed in anal (*C. indentata*, *C. valerieae*), aggenital (*C. indentata*, *C. tofinoensis*), and notogastral setae (*C. tofinoensis*) among the species examined herein. Notogastral setae expression among the Gustavioidea, including three species of *Ceratoppia* were the topic of recent discussion by Seniczak & Seniczak (2010), however further consideration is warranted in light of species described here. The dominant character state of notogastral expression among the *Ceratoppia* is two pairs of posterior seta (p_1, p_3) expressed (e.g. *C. quadridentata*, *C. sphaerica* and *C. bipilis*) as described in Seniczak & Seniczak (2010), and a subdominant character state of three pairs of posterior notogastral seta expressed (h_1, p_2, p_3) (e.g. *C. sexpilosa*) (Seniczak & Seniczak 2010). In all *Ceratoppia*, the setae *la*, *lm*, *lp*, h_3 and h_2 are vestigial. *Ceratoppia tofinoensis*, *C. valerieae*, and *C. offarostrata* conform to the dominant character state of two pairs of (p_1 and p_3) posterior setae, although the length of these setae vary among species, and in C. *tofinoensis*, h_1 alveoli are replaced with minute depressions. *Ceratoppia indentata* has an unusual pattern of notogastral expression in that h_1 rather than p_1 are expressed in conjunction with p_3. In both *C. bipilis* and *C. quadridentata arctica*, the h_1 alveolus is directly anterior and dorsal to p_1, while in *C. indentata* the p_1 alveoli are well removed posteriorly and mediad to h_1, therefore it is unlikely that p_1 and h_1 setae have simply shifted in position, although variation in the position of the posterior alveoli in relation to the expressed setae was observed for all species. In *C. longicuspis*, there are three pairs of posterior notogastral setae which are short, and in particular, setae p_2 are minute and not observable in most specimens. While *C. longicuspis* posterior setal expression is similar to *C. sexpilosa* with three pairs of posterior setae, it is p_1 rather than h_1 that is expressed with, p_2 and p_3, similar to *Gustavia fusifer*. Among the Gustavioidea, Seniczak & Seniczak (2010) note that the variability of notogastral setae character states lowers the value of using this character to explain the phylogeny of this group.

In the course of preparing for this manuscript, observations were made regarding morphology and distribution for previously described *Ceratoppia* in North America. It is worth noting that *Ceratoppia bipilis* is a highly variable species as presently conceived; at least two morphological forms are present in North America, both co–occurring in northern, Boreal forests of Canada (pers. obs.; D. Walter, pers. comm.) alongside *C. quadridentata arctica*. The main qualitative difference among these morphological variants is size and colour (darkness). Larger, darker forms are similar to European species of *C. bipilis*, while smaller, lighter forms are nearly indistinguishable from *C. quadridentata arctica* with the exception of the number of hypostomal setae. Further investigation, and molecular information for the two *C. bipilis* morphotypes and *C. quadridentata arctica* is warranted. Grandjean (1936) noted that the variation in many characters of *C. bipilis* (e.g. rostral tips, the length of the lamellar cusps, outer rostral teeth, prodorsal setae including the bothridial setae, and overall body size and colour) may be due to geographical variation and ecology. Numerous subspecies have been proposed for *C. bipilis* including *C. bipilis spinipes* originally described from east-central North America (Church Falls, Virginia) (Banks 1906). Type specimen (slide mounted and alcohol specimens) by Banks (1906) supplied by the Museum of Comparative Zoology reveal high variation in size among the *C. bipilis spinipes* type specimens themselves. While the observed specimens of *C. bipilis spinipes* are generally smaller (480–800 µm) than *C. bipilis* (600–1100 µm), the size range overlaps, and at present, no single diagnostic character, or unique set of character states differentiate *C. bipilis spinipes* from the smaller morpho-type of *C. bipilis* present in northern North America. A full revision, with molecular information, is suggested for the *C. bipilis* complex.

Both *Ceratoppia quadridentata* and the subspecies *C. quadridentata arctica* are listed for northern North America (Marshall *et al.* 1987), and are primarily differentiated by the length of the lamellar cusps. The validity of

C. quadridentata arctica as a subspecies has been questioned. Marshall *et al.* (1987) note that although they list *C. quadridentata arctica* as a subspecies, *C. quadridentata* contained a number of geographical forms that are difficult to separate. It is likely that records of *C. quadridentata* and *C. quadridentata arctica* in Canada represent the same species. Similarly, variation in the lamellar cusps noted for specimens of *C. sphaerica* collected from western arctic North American (Alaska) and Eastern Russian led to these specimens differing from the re-description of *C. sphaerica* by Hammer (1944) (pers. obs.). Lack of a type specimen and poor original description for *C. sphaerica* are described above in the remarks for *C. offarostrata* and previous identification issues are noted in the literature. For example, Grandjean (1936) noted that specimens of *C. sphaerica*, collected by Trägårdh, were confirmed by Koch. However, it was noted that these specimens did not match Koch's own description or the original drawings of *C. sphaerica* by Koch (Grandjean 1936). These issues may indicate that there is variation within the species among the diagnostic character states used, and/or that *C. sphaerica* may represent a more variable species complex than previously thought, which may or may not include *C. offarostrata*.

Species complexes (subspecies designations and variation within species across distributional ranges) may arise due to plasticity in character states or changes in character states following vicariance events (i.e. isolation of populations) leading to speciation. A greater understanding of variation in character states within and among species of *Ceratoppia* will help identify which character states are more conservative, and therefore more useful (or reliable) for species-level identification. Further, molecular sequencing could clarify species overlap within complexes, and the use of multiple genes (or genome sequencing) would help with phylogenetic relationships among the *Ceratoppia*.

Distribution of *Ceratoppia* in western North America

All species described here are considered to have a North American coastal temperate rainforest distribution (Fig. 39). *Ceratoppia indentata* and *C. longicupsis* are the dominant *Ceratoppia* for temperate rainforests on the west coast of North America. *Ceratoppia tofinoensis* has a restricted distribution within the Pacific Northwest, however, this may reflect sampling bias due to a strictly arboreal habitat. All species except *C. valerieae* appear endemic to this rare ecozone. *Ceratoppia valerieae* is frequently encountered in coastal forests, generally occurring in low abundance, yet is the dominant *Ceratoppia* for interior southern British Columbia through to southwestern Alberta. The distribution range of *C. offarostrata* appears limited to coastal locations on Vancouver Island and Haida Gwaii, British Columbia, but could be due to habitat specificity. Variation in body size and relative lengths of posterior setae were observed in northern and southern range for *C. valerieae*, and southern populations of *C. indentata*. *Ceratoppia offarostrata* exhibited variation in posterior setae length on Haida Gwaii, where specimens collected had slightly shorter posterior setae and reduced rostral bump.

North American coastal temperate rainforests have high tree and other plant diversity, high habitat heterogeneity and diversity of microhabitats compared to other temperate or boreal forest systems. Well-developed forest floor organic layers, long-lived trees with complex architecture, and epiphytic plant and lichen habitats may also help explain the high oribatid mite diversity encountered in these forests. However, why *Ceratoppia* and other members of the family Peloppiidae are especially species rich in these systems remains unclear.

In addition to the five new species I describe, *C. quadridentata arctica* was observed on the west coast of Vancouver Island, British Columbia within the temperate rainforest biogeoclimatic zone, however, only in alpine and high elevation areas. Hammer (1955) first described the subspecies of *C. quadridentata* (*C. quadridentata arctica* Hammer, 1955) from Alaska. In Canada the subspecies has been found in the three northern territories, and northern areas of Alberta, Quebéc, and Newfoundland, however a wider distribution of *C. quadridentata arctica* is suspected. For example, in collections for western Canada, *C. quadridentata arctica* was found in samples from northern British Columbia (Charlie Lake, Fort St. John), as well as high elevation and subalpine areas of the British Columbia temperate zone (Heather Mt. subalpine, Vancouver Island, at 1097m; Comox Glacier meadow, Vancouver Island, at 1840m; Lost Shoe Creek at Hwy 4, Vancouver Island; Manning Provincial Park, at 1768m).

Increased sampling efforts will reveal more robust distribution patterns for all species of *Ceratoppia* in North America. For example, in Canada, *C. bipilis* (Hermann, 1804) is known from all provinces and territories except British Columbia and Saskatchewan, but given its holarctic distribution (e.g. Sweden, England, France, Germany, Italy, Holland, Switzerland) (Trägårdh 1910) and presence in northern regions of other Canadian provinces, further sampling will probably reveal this species in the northern areas of these provinces. Other *Ceratoppia* listed for

Canada appear well defined, but less common. For example, *C. sexpilosa* has been recorded from eastern Russia, and Yukon Territory, while *C. sphaerica* is listed in Canada from the northern territories, and has a Boreal forest distribution (Siberia, East Greenland) (Trägårdh 1910). Additionally, there are possibly three (or more) undescribed species from eastern North America.

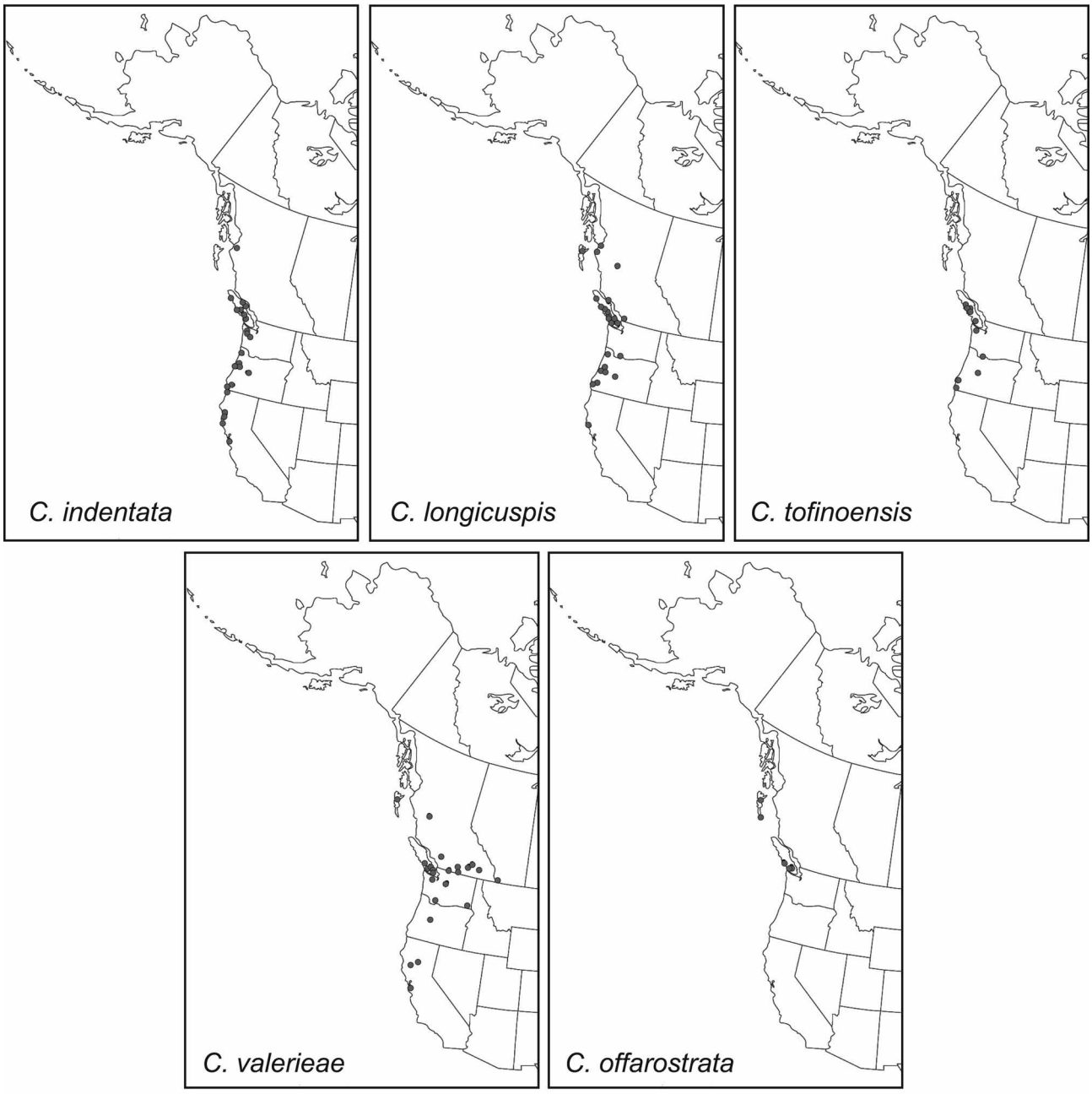


FIGURE 39. Distributional maps for five new species of *Ceratoppia* in western North America based on previously collected samples and specimens observed from Canada (Yukon Territory, British Columbia, Alberta) and United States (Alaska, Washington, Oregon, California). Refer to individual species descriptions for location name and co-ordinates."

Key to adults of species of *Ceratoppia* known from North America

1. Mentum of subcapitulum with two pairs of hypostomal setae 2
- Mentum of subcapitulum with one pair of hypostomal setae 3
2. Two pairs of long posterior notogastral setae (p_1, p_3) . . . . . *C. bipilis* (Hermann) group (Holarctic, widespread in North America)
- Two pairs of very short posterior notogastral setae (p_1, p_3) . . . . . *C. valerieae* **n. sp.** (known from BC, AB, WA, OR, CA)

3. Two or three pairs of conspicuous notogastral setae 4
- Notogastral setae reduced, much shorter than length of rostral setae 8
4. Three pairs of notogastral setae long, conspicuous (h_1, p_2, p_3) . . . . . *C. sexpilosa* Willmann (known from AK, YK, NT, NU)
- Two pairs of conspicuous notogastral setae 5
5. Rostrum deeply indented with inset medial tooth; interlamellar setae distinctly shorter than length of lamellae; notogastral setae h_1 and p_3 expressed; barbed epimeral setae (3–1–2–3). . . . . *C. indentata* **n. sp.** (known from BC, WA, OR, CA)
- Rostrum not deeply indented, rounded (dentate) or with large medial tooth 6
6. Rostrum with strong medial tooth and lateral denticles; lamellae reaching insertion of rostral setae; interlamellae setae as long or longer than lamellae . . . . . *C. quadridentata* (Haller) group (Holarctic, widespread in northern North America)
- Rostrum rounded anteriorly, dentate, but without medial tooth; lamellae not reaching insertion of rostral setae 7
7. Large (700–1000 um); dark (almost black) in colour; lamellar setae longer than rostral setae; interlamellar setae as long as prodorsum, longer than lamellae; lamellae short cusps; two pairs of medium length posterior notogastral setae (p_1, p_3). . . . . *C. sphaerica* (L. Koch) (known from AK, YK, NT, NU)
- Smaller species (550–650 um), reddish in colour, with prominent rostral bump in lateral view; two pairs of medium length posterior notogastral setae (p_1, p_3). . . . . *C. offarostrata* **n. sp.** . . . . . .(known from BC)
8. Three pairs of reduced notogastral setae (p_1, p_2, p_3), in particular setae p_2 minute, not discernable in all specimens; lamellae long, reaching insertion of rostral setae, with 2/3 free cusps; lamellar setae reduced, much shorter than rostral setae; large medial rostral tooth with lateral denticles; interlamellar setae long, reaching past tips of lamellae. . . . . *C. longicuspis* **n. sp.** (known from BC, WA, OR, CA)
- Two pairs of reduced notogastral setae (p_1, p_3); lamellae with short cusps, not reaching insertion of rostral setae; interlamellar setae longer than lamellae; wide medial rostral tooth; smaller species (530–580 um). . . . . *C. tofinoensis* **n. sp.** (known from BC, WA, OR)

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