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A New Species of *Adalaria* (Nudibranchia: Onchidoriididae) from the Northeastern Pacific

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A new species of *Adalaria* Bergh, 1878 is described from the northeastern Pacific. It is white, characterized by highly spiculose, rounded tubercles with narrow bases, 4-6 tubercles on the rhinophore sheath, and separate gill leaves inserted in a circlet. This species is known to range from Alaska to Oregon. A comparison is made between this new species and others in the genus.

KEY WORDS: *Adalaria*, *Arctadalaria*, Onchidoriididae, phanerobranch, Nudibranchia, Northeastern Pacific

The genus *Adalaria*, in the family Onchidoriididae, is composed of small white, off-white, or yellow phanerobranch dorid nudibranchs with a spiculose dorsum and tubercles, an ample mantle margin, lamellate rhinophores and a veil-like head. They are bryozoan feeders and are similar to another bryozoan feeding genus, *Onchidoris*, which are usually white or brown in colour. Both genera have a reduced or absent, rectangular central tooth, a large, flat, beak-like first lateral tooth, which may have a few inner denticles, and small, oval, outer lateral teeth with a small hook. *Adalaria* are distinguished by having more than one outer lateral tooth and by usually having a smooth rather than a papillate lip disk, although *A. jannae* Millen, 1987 has a papillate lip disk. Both genera have a short, wide ampulla, a wide unarmed penis and a correspondingly wide but short vagina (Millen 1985, 1987). An exception is *Onchidoris bilamellata*, which has a longer, narrow, chitinized penis, without spines, and a longer narrower vagina. There are two bursae, the oviduct usually enters near the base of the sessile receptaculum seminis and the insemination duct to the female gland mass is near the base of the bursa copulatrix, as illustrated for *Onchidoris bilamellata* by Thompson (1966:350, Fig. 2). All species in both genera are cold-water northern species. Based on the phylogenetic analysis by Millen and Martynov (2005), the genus *Adalaria* is situated in a clade with *Onchidoris* and the family Corambidae genera *Corambe* and *Loy*. A sister clade includes other Onchidoriididae genera *Calycidoris, Diaphorodoris, Acanthodoris* as well as *Goniodoris*. The latter genus had previously been placed in the family Goniodoriididae. A more recent analysis by Fahey and Valdés (2005) which did not include the family Corambidae genera, placed *Adalaria* as a sister genus to *Onchidoris* and that clade as basal to *Acanthodoris* and a sister clade containing *Calycidoris Diaphodoris* and two genera of Goniodoriididae (*Goniodoris* and *Okenia*). Although the relationship of these three families needs further exploration, it is clear that *Adalaria* and *Onchidoris* are closely related genera.

There are two species of *Adalaria* known to occur in the Atlantic, White, and Barents Seas, *A. loveni* (Alder and Hancock 1862) and *A. proxima* (Alder and Hancock 1854), and three are recorded from the Bering Sea, Sea of Okhotsk and Sea of Japan, but, in this region, the genus is currently being reassessed (Martynov, pers. commun.). *Adalaria proxima s.l.* is rarely found subtidally in

all three seas. *Adalaria jannae* is a common intertidal species in Peter the Great Bay in the Sea of Japan and extends to the northern Kurile Islands (Martynov 2005). *Adalaria tschuktschica* Krause, 1885 (sometimes as its junior synonym *Arctadalaria septentrionalis* Roginskaya, 1971) has been reported from the Laptev and Chukchi Seas (Martynov 2001). *Adalaria spiculoides* (Volodchenko, 1941) is a *nomen dubium* according to Martynov (1997). Volodchenko determined two other specimens under this name, which are similar to *Onchidoris muricata* with the radulae absent. *Adalaria beringi* (Volodchenko, 1941) is a *nomen dubium* and other specimens determined by this name by Volodchenko appear to be similar to *Onchidoris muricata* with the radulae absent, according to Martynov (1997). Two additional, apparently undescribed species have been collected from the northern Sea of Japan and Kurile Islands; one is photographed in Nakano (2004:98 #191). In the northeastern Pacific, two species of *Adalaria* are found; *Adalaria proxima* and *A. jannae*. Both species are sympatric with the newly described species (Millen 1987).

A small, white, undescribed dorid nudibranch belonging to the genus *Adalaria* has been collected sporadically in Oregon (Goddard 1984), British Columbia (Millen 1987) and Alaska (Millen 1989; Goddard and Foster 2002). In 1987, a substantial population was discovered near Horseshoe Bay, British Columbia, and specimens were collected over several months. This paper describes the new species and compares it with other species of *Adalaria*.

Subclass Opisthobranchia
Order Nudibranchia
Suborder Doridacea
Superfamily Anadoridoidea
Family Onchidorididae Gray, 1827

Genus *Adalaria* Bergh, 1878

TYPE SPECIES: *Doris loveni* Alder and Hancock, 1862.

Adalaria evincta **Millen sp. nov.**
Figs. 1–3.

Adalaria sp. Goddard 1984:145, 155–156, 159, Tbls. 1,2,3.
Adalaria sp. Millen 1987:2701.
Adalaria sp. Millen 1989:66.
Adalaria sp. 1. Behrens 1991:50,fig. 67.
Adalaria sp. Goddard et al. 1997: Tble. 1 pg. 294.
Adalaria sp. 1. Goddard, 2005: Tble. 1. pg. 1959.
Adalaria sp. 1, Goddard and Foster 2002:333.
Adalaria sp. 1, Behrens and Hermosillo 2005:58.
Adalaria MC309. Lamb and Hanby 2005:256.

ETYMOLOGY.— The species name *evincta* (L. wreath or crown) refers to the crown of spines found on each tubercle.

MATERIAL EXAMINED.— Holotype: California Academy of Sciences, CASIZ 110799. 20 March 1987, Tyee Pt., Copper Cove, Horseshoe Bay, British Columbia, Canada (49°22′8″N, 123°16′5″W), 2 m depth on the bryozoan *Dendrobenia lichenoides*, rock substrate. S. Millen. Paratypes: Royal British Columbia Museum, RBCM 988-25-1, 5 specimens, collected with the holotype on March 20, 1987 by S. Millen; RBCM 975-230-2, 1 specimen, collected Georgeson Passage, between Maine and Samuel Is., June 27, 1975; RBCM 976-1040-15, 1 specimen, collected Langara Island, Queen Charlotte Islands, Dribrell Bay, March 30, 1976.

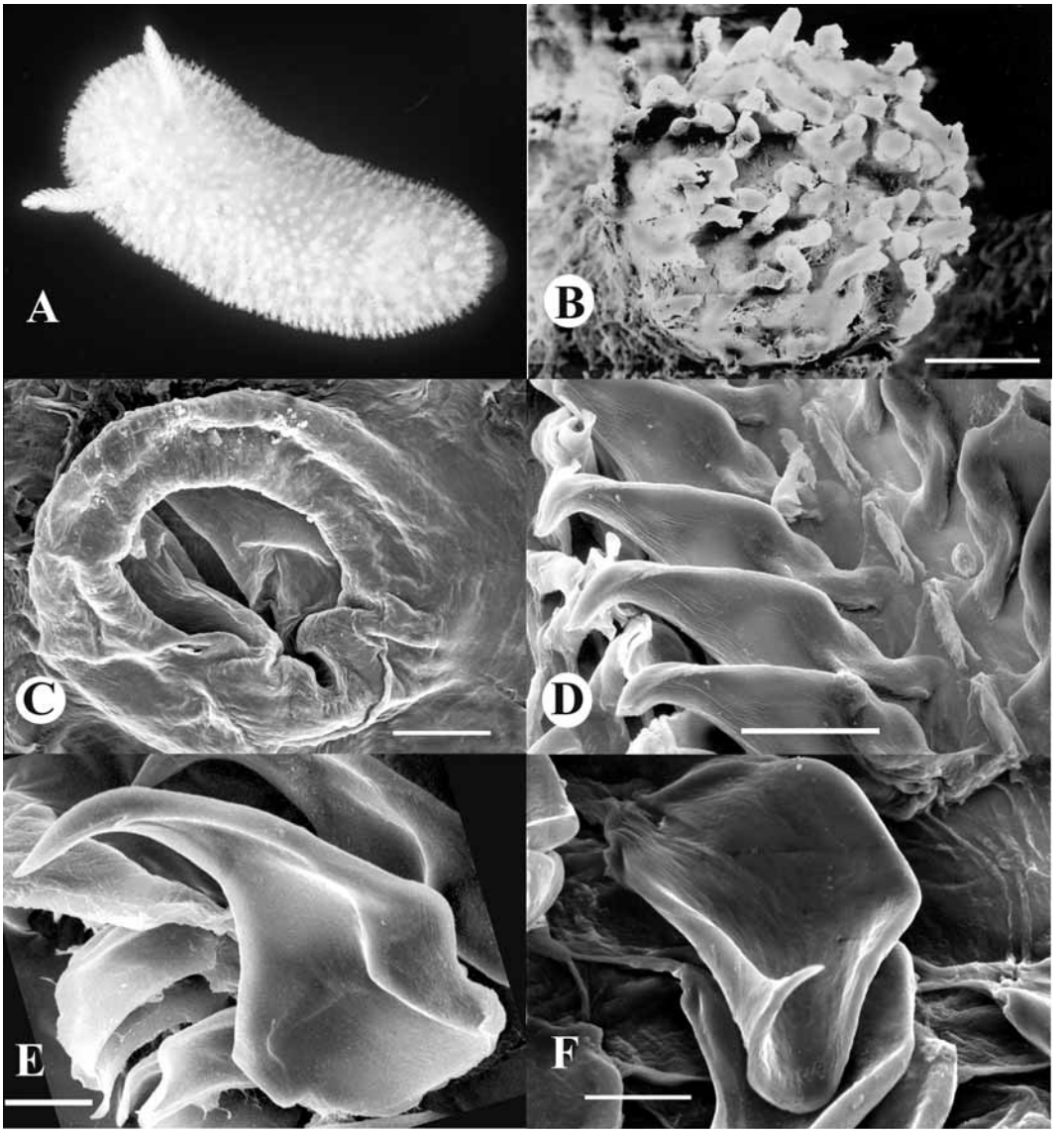

FIGURE 1. *Adalaria evincta* sp. nov. A. Living animal. Specimen from Bowen Island, British Columbia, Canada, March, 1974. Photo by Ron Long. B. SEM of tubercle with spines. Scale bar = 100 µm. C. SEM of lip disk. Scale bar = 100 µm. D. SEM of the radula showing central and lateral teeth. Scale bar =50µm. E. SEM of the first lateral tooth. Scale bar = 20 µm. F. Outer lateral tooth. Scale bar = 10 µm.

EXTERNAL MORPHOLOGY.— The body shape is elongate-oval and tapering, wider in front than behind (Fig. 1A). Specimens range in size from 7–14 mm (preserved lengths) the largest having a live length of 16 mm. The mantle margin is narrow, covering the sides and head but not the flattened tail, which tapers to a rounded tip. The notum bears tubercles with rounded spiculose tops and long narrow stalks (Figs. 1B, 2A). The closely spaced tubercles vary in size with smaller tubercles predominating towards the mantle margin. Larger tubercles are 0.9 mm high and 0.5 mm wide at the top with a stalk diameter of 0.2 mm. The tubercle stalks are densely packed with vertical

spicules, which, at the top, radiate out at an angle of approximately 15° from the central axis, creating a spiculose crown. At the bases of the tubercles, spicules extend in a conspicuous radial, star-like pattern throughout the notum. Elsewhere in the notum larger spicules are visible over the dark background of the digestive glands and sperm filled bursa copulatrix, where they can be seen running crosswise to the body axis. In the foot, the spicules form a reticulating network, which is radially arranged towards the outside. The rhinophores contain a central shaft of spicules and small supporting spicules on the lamellae.

The margins of the rhinophores are slightly raised and bear from 4–7 (usually 5) tubercles of various dimensions. The branchial circlet contains 4–9 tubercles of varying sizes within it and tubercles surround the outsides of the gill pockets. There are 6–13 pinnate gill leaves with long irregular side branches. These contract into separate gill depressions arranged in a nearly complete circle. The gill leaves are longer anteriorly, slightly shorter posteriorly (1.9 and 1.2 mm respectively in one live specimen). The rhinophores are long and slender with a rectangular, flat-topped tip. The stalk is short and the clavus bears sloping lamellae. The 11–17 (usually 15) lamellae are attached along a vertical anterior line. The lamellae slope ventrally and the distal most 4–10 meet posteriorly forming a chevron. More proximally the lamellae are progressively more incomplete. The large head (Fig. 2B) is veliform, semi-circular with a ruffled or smooth outer edge. Small notches separate leaf-like tentacles attached at their posterior edge. The mouth is a small vertical oval. The triangular foot is wider and thickened anteriorly, with rounded front corners. It tapers to a slightly protruding, narrow, rounded tail.

Living specimens are white, occasionally pale yellow and semi-translucent. In mature animals the mid-dorsal region appears yellowish due to the creamy gonads underneath. Sometimes there is a brown spot slightly to the right of the midline indicating the location of the sperm filled bursa copulatrix. In immature animals, the small digestive glands, which are dark brown or reddish brown, can be seen dorsally as well as ventrally. The rhinophores are pale yellow. The gill leaves and foot are white or pale yellow. The gill leaves have opaque white glands on their bases. On the midline, posterior to the branchial circlet, a mantle gland is visible as a small circular area of opaque white granulations.

Anatomy.— The buccal tube is short and broad, internally folded and glandular. Dorsally the buccal bulb has a rounded sucking crop with a broad median muscular band and a short stalk. The posterior radular sac projects ventrally. It is long and narrow, usually bent to one side. The lip disk is smooth, thin and light yellow (Fig. 1C). Two small ventral flaps guard the opening. The radula ranges in length from 34–39 rows. The radula (Figs. 1D– F; 2C) has a formula of 3-6.1.1.1.3-6. The central (rachidian) tooth is a narrow elongate rectangle with thickened sides and rounded ends. Central tooth lengths ranged from 0.03–0.04 mm (x= 0.04 mm, n=19). Each large inner lateral tooth has a triangular base and an elongate hook. The anterior edge of the hook is straight and the tip curves suddenly. The hook is usually smooth but larger specimens had 1–12 tiny denticles along the upper edge, which do not extend to the tip. A large inner, wing-like knob is present. The inner lateral teeth range in height from 0.08–0.10 mm (x=0.09, n=23). The outer lateral teeth are somewhat oblong with rounded edges. The anterior edge is thickened and recurved with a single posteriorly directed hook. The outer lateral teeth are smaller towards the outside of the radula and assume a triangular shape. Outer lateral tooth heights ranged from 0.01–0.04 mm (n=21).

At the posterior end of the buccal bulb is the long, thin esophagus. The salivary glands insert at its base. They are white, S- shaped, with a thicker, fluffy anterior portion. The small stomach is buried in the digestive glands anteriorly but posteriorly it loops up to the surface where a small, cylindrical caecum lies under the loop of the intestine. The digestive glands appear as one elongate oval, dark brown mass, hollowed out on the anterior right due to the reproductive organs. The tubu-

lar intestine curves to the right over the caecum and runs to the anus located slightly left of center in the branchial circlet. The anal opening is simple and not raised, located at the base of a large posterior tubercle. The renal pore is located slightly to the right at the base of the same large tubercle.

The Circulatory system has a thin walled, triangular auricle and a smaller, slightly thicker walled, diamond shaped ventricle. The aorta ends in large, fluffy, white blood glands appearing as one mass covering the central nervous system.

In the central nervous system, the cerebral and pleural ganglia are partially fused. The cerebral ganglia are oval and connected by a short commissure. The pleurals are oval and lie ventral and lateral to the cerebrals. Dorsally they are separated from the cerebrals by a groove and have larger nerve cells. Ventrally the cerebro-pleurals form an almost indistinguishable mass. The almost separate pedal ganglia are posterior, oval and nearly as large as the combined cerebro-pleurals. They are connected by a short commissure. The eyes are connected by a short optic nerve. The small olfactory bulbs are unstalked. The paired buccal ganglia adjoin each other and each has a gastro-esophageal ganglia attached by a short stalk.

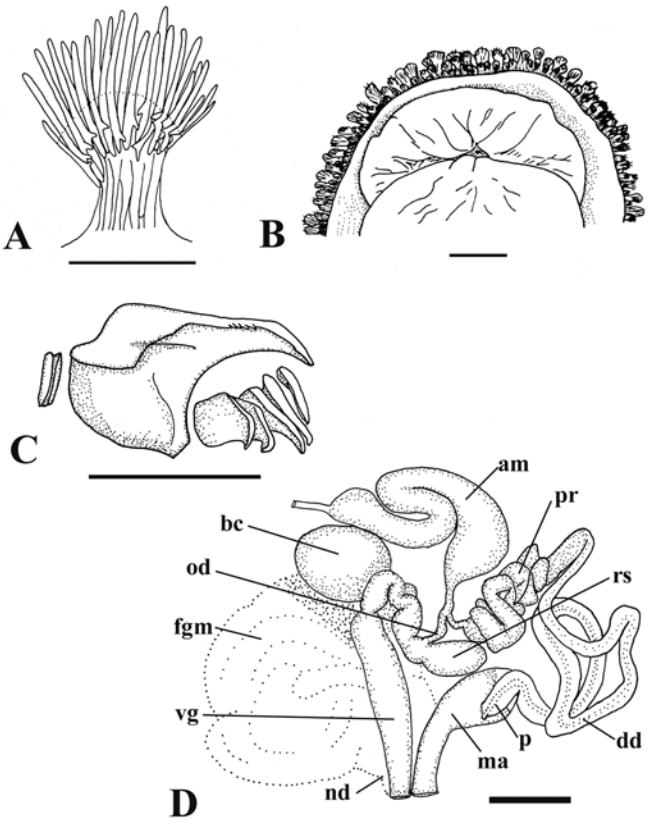

FIGURE 2. *Adalaria evincta* sp. nov., drawn by camera lucida. A. Notal tubercle . Scale bar = 0.5 mm. B. Head. Scale bar = 1 mm. C. Radula. Scale bar = 0.1 mm. D. Reproductive system. Scale bar = 1 mm. Key: am= ampulla, bc=bursa copulatrix, dd=deferent duct, fgm=female gland mass, ma=male atrium, nd=nidamental duct, od=oviduct, p=penis, pr=prostate, rs=receptaculum seminis, vg=vagina.

The ovotestis consists of creamy yellow lobules on the dorsal surface and sides of the digestive glands. The branched gonoducts of the ovotestis merge forming a thin pre-ampullary duct, which widens into a S-shaped ampulla (Fig. 2D). The postampullar duct bifurcates into a short oviduct leading to the buried receptaculum seminis (fertilization chamber) and an extremely long vas deferens. The proximal, prostatic, portion of the vas deferens is highly coiled, soft and glandular. It continues as a less coiled, muscular deferent duct. Near the outer body wall the vas deferens enters an enlarged male atrium with highly folded walls. The penis is cylindrical and unarmed. The oval receptaculum seminis is hidden within the albumen gland and has a wide, muscular duct. The bursa copulatrix has a short duct leading to a large, round sac, which is dark brown when filled with unaligned sperm. The proximal portion of the vagina is free of the female gland mass and has an insemination duct on the inner side. Distally, the vagina is a soft, cylindrical duct, which is open to the female gland mass on the inner side. The female gland mass consists of a granular yellow albu-

men gland which is anterior, a highly convoluted mucous gland and an elongate, less convoluted, white membrane gland. The latter envelopes the other two glands and forms the nidamental duct that is attached to the inner side of the vagina and opens ventral to the vagina.

The reproductive openings are located under the notum on the right side on a small papilla a short distance posterior to the anterior margin of the foot. The penial opening is round, the common vaginal and oviductual opening forms a crescent shape posterior to the male opening.

Natural history.— *Adalaria evincta* occurs in the low intertidal zone and shallow subtidal to 15 m. Its known range is from Tatitlek, Alaska (60°52.10′N, 146°43.47′W) to North Cove, Cape Argo, Oregon (43°20′N, 124°22′W) (Goddard 1984; Goddard and Foster 2002). According to Goddard (1984) this species eats the white encrusting bryozoan *Hincksina minuscula* (Hincks, 1822) at his study site in Oregon. In British Columbia, this species was consistently found feeding and spawning on the pale brown bryozoan *Dendrobenia lichenoides* (Robertson, 1905). *Adalaria evincta* has been found year round, predominately January to March, although it is never abundant (Fig. 3). Spawning has been observed from late January to May. The egg mass, a white ribbon on edge with 2–3 turns and larval development has been described by Goddard (1984:145, Table 1).

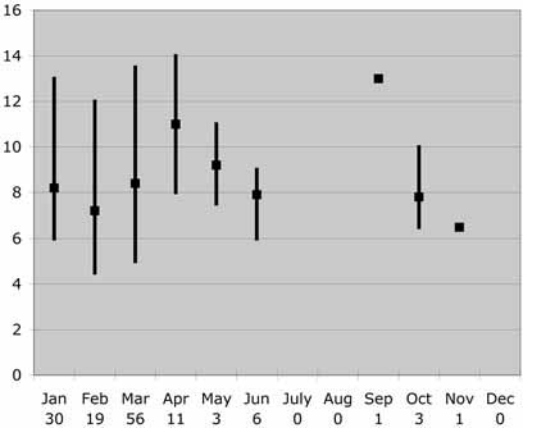

FIGURE 3. *Adalaria evincta* sp. nov. annual cycle. Preserved length of specimens in mm showing the range and average versus month collected. Number of specimens noted with the month. N=130.

Discussion.— This new species is placed in the genus *Adalaria* because it has pinnate gill leaves inserted into separate notal areas and several outer lateral teeth. Externally it differs from most other *Adalaria* species in having an elongate, tapering shape, tubercles which have projecting spicules, many tubercles around the rhinophores and gill leaves arranged in a circlet rather than a horseshoe. These latter two features were considered sufficient by Roginskaya (1971), to create a new genus, *Arctadalaria*. I consider them insufficient to be considered a generic difference and agree with Martynov (2001) that *Arctadalaria* is a junior synonym of *Adalaria*. Along the northeastern Pacific coast, only *Adalaria albopapillosa* Bergh, 1880 from Sitka, Alaska is like *Adalaria evincta* in having similar sized (1mm long) tubercles with projecting spicules. It differs in having fewer radular tooth rows (29–30 vs. 34–39) and more outer lateral teeth (8 vs. 3–6). The lateral teeth are larger (12 mm vs. 9 mm), with stronger denticulations and a curved anterior edge. In addition, the body shape is oval and there are only 2 tubercles guarding the rhinophores. These features are more consistent with *Adalaria proxima* than with *Adalaria evincta* as poorly preserved specimens of *Adalaria proxima* often show projecting spicules. I therefore continue to consider *Adalaria albopapillosa* as a junior synonym of *Adalaria proxima* (Millen 1987).

In the Bering and Laptev Seas, three species have been described with a similar tooth shape and several tubercles around the rhinophores. *Adalaria tschuktschica* from the Bering Sea has an elongate body form and a similar radular formula 39 (7.1.1.1.7). The teeth differ in that the inner laterals are more strongly denticulate and the tip is straighter. Other differences are the longer (2mm vs. 0.9 mm) cylindrical tubercles and the larger body size (22 mm vs. 14 mm preserved lengths). *Arctadalaria septentrionalis* from the Laptev Sea, was described as having projecting spines along the length of the tubercles, like a pinecone. The gill leaves are arranged in a circlet but they have

common rather than separate insertions and the anterior most gills are tripinnate. This species, according to Martynov (2001) is a junior synonym of *Adalaria tschuktschica*. *Adalaria spiculoides* (Volodchenko, 1941), a *nomen dubium* from the Bering Sea has lateral teeth, which have longer and straighter hooks, the tubercles are cylindrical conical, and the body spicules are more developed. It has an elongate body shape, gill leaves in a circlet, tuberculate rhinophore sheaths and its radula formula of 33 (5.1.1.1.5) overlaps that of *Adalaria evincta*. *Adalaria beringi* (Volodchenko, 1941), another *nomen dubium* from the Bering Sea has a similar radula formula 39 (5.1.1.1.5). It has a longer, straighter hook on the lateral teeth, and the outer lateral teeth have a serrated margin. Other differences are its oval shape, equally rounded at both ends, with a thin wide mantle margin, small head with pointed tentacles, smooth rhinophore and gill margins and a common gill opening. None of these species have cylindrical spines ending in a round ball with projecting spicules that are so obvious on *Adalaria evincta* and they all have straighter tipped, less abruptly hooked lateral teeth than does *Adalaria evincta*.

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