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Red Octopus, *Octopus rubescens* Berry, 1953 (Cephalopoda: Octopodidae), in the Mexican tropical Pacific

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Abstract

"*Octopus*" *rubescens* Berry, 1953 is an octopus of temperate waters of the western coast of North America. This paper presents the first record of "*O.*" *rubescens* from the tropical Mexican Pacific. Twelve octopuses were studied; 10 were collected in tide pools from five localities and two mature males were caught by fishermen in Oaxaca. We used morphometric characters and anatomical features of the digestive tract to identify the species. The five localities along the Mexican Pacific coast provide solid evidence that populations of this species have become established in tropical waters.

Keywords

Artisanal fishery, cryptic species, Gulf of Tehuantepec, Oaxaca, *Octopus*

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Introduction

Nowadays, the generic status of most octopus species is unresolved generic and only nine species belong to *Octopus* Cuvier, 1797 *sensu stricto*. Other *Octopus*-like species that have been provisionally placed in the genus *Octopus* (denoted with quotation marks to indicate their unknown position) are awaiting generic revision (Norman et al. 2014). In the Mexican Pacific, the following species have been described: "*O.*" *bimaculoides* Pickford & McConnaughey, 1949; "*O.*" *bimaculatus* Verril 1883; "*O.*" *mimus* Gould, 1852; "*O.*" *hubbsorum* Berry, 1953; "*O.*" *chierchiae* Jatta, 1889; "*O.*" *alecto* Berry, 1953; "*O.*" *fitchi* Berry, 1953; "*O.*" *veligero* Berry, 1953; "*O.*" *penicillifer* Berry, 1954; "*O.*" *oculifer* Hoyle, 1904; and "*O.*" *rubescens*. However, there is little information on their geographic distribution.

"*Octopus*" *rubescens* Berry, 1953, Red Octopus, is

a small benthic octopus that reaches an average adult weight of 150–200 g, although some can reach as much as 400 g in weight (Hochberg 1997). Its life cycle spans from 12 to 18 months. It is a migratory species, moving offshore in the winter months. Its mating occurs in deep waters in the spring, followed by an onshore migration before spawning (Norman et al. 2014). The female has an average fecundity of 20,000 to 50,000 eggs (3–4 mm in length; mantle length (ML) of the pelagic paralarvae 1.7–2.0 mm) (Hochberg 1997).

This species is native to the temperate waters of the western coast of North America, inhabiting an extremely wide variety of habitats, including soft bottoms, rocky inshore and intertidal areas, and mud bottoms, from the intertidal zone to 300 m deep (Norman et al. 2014). It has a nocturnal and cryptic behavior, and its diet includes gastropods, bivalves, and decapod crustaceans (Hochberg and Fields 1980). "*Octopus*" *rubescens* is a prey for many marine species, including fishes, birds, and mammals (Norman et al. 2014). This species is commonly known as Red Octopus, and its distribution comprises the southern part of the Gulf of California, Mexico, to the Gulf of Alaska (Hochberg and Fields 1980). We present here the first confirmed occurrences of "*O.*" *rubescens* from Mexican tropical Pacific waters. These new records represent the southernmost limit of the geographic distribution of this species.

Methods

From December 2015 to February 2016 during a scientific research expedition in the eastern Pacific, 10 specimens of "*Octopus*" *rubescens* were encountered during several scientific dives in shallow waters (Fig. 1). Specimens were collected with clove oil (Seol et al. 2007) under two scientific collection permits, PPF/DGOPA-035/15 and PPF/DGOPA-116/17 issued by SAGARPA and CONAPESCA. Two additional specimens were caught on 18 February 2016 in El Faro, Puerto Angel, Oaxaca by fishermen, while diving at depths of 5 and 15 m and using a long hand hook. These specimens were fixed in 96% alcohol for 24 h, preserved in 70% alcohol, and deposited at the Cephalopod Collection of the Universidad del Mar (UMAR-CEPHA).

Octopuses were identified according to Roper and Voss (1983) and Hochberg (1998). Measurements were taken from each individual using digital calipers to the nearest 0.01 mm. All measurements and counts are as defined by Roper and Voss (1983). Measurements included: TL = total length; ML = dorsal mantle length; VML = ventral mantle length; MW = mantle width; HL = head length; HW = head width; AL = arm length; HAL = hectocotylized length; AW = arm width; WD = web depth; FL = funnel length; FFL = free funnel length; LL = ligula length; CL = calamus length. Sucker counts are totals per each intact arm. Gill counts do not include

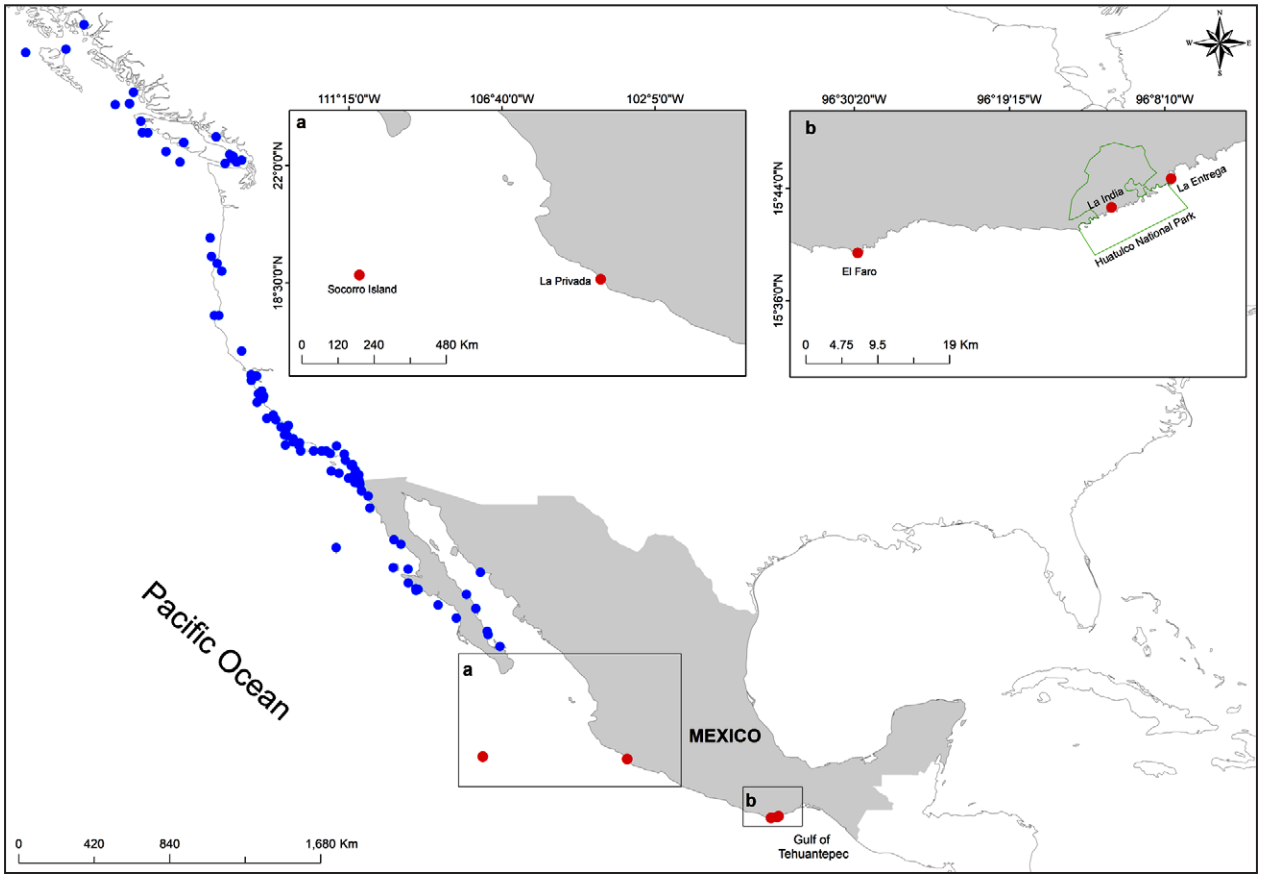

Figure 1. "*Octopus*" *rubescens* distribution on the Pacific coast. Blue points = previously known distribution, records obtained from GBIF. Red points = new records, this study.

terminal lamella. The measurements were provided as proportions of ML using the mantle proportion length index proposed by Roper and Voss (1983).

Total weight (W) was measured to the nearest 0.1 g. Sex was established through the observation of the gonads in all mature and immature specimens. The comparison of sexes was made only with adult individuals.

Results

Twelve records of "*Octopus*" *rubescens* from six localities in the Mexican tropical Pacific are presented here (Table 1). Juveniles and mature females were recorded in tide pools.

Materials examined. MÉXICO – **Colima** • Revillagigedo Archipelago National Park, Socorro Island, Braulia tidepool; 18°43′53″N, 110°57′20″W; 15 Dec. 2015; O. Valencia leg.; tide pool, scuba; UMAR-CEPHA 1153–1156 (4 ♀,13.3, 19.1, 25.0, 31.61 mm ML) – **Michoacán** • playa La Privada; 18°36′15″N, 103°42′29″W; 12 m depth; 24 Feb. 2016; UMAR-CEPHA 1157–1160 (2 juveniles, 5.5, 9.57 mm ML, 2 ♂, 20.2, 21.2 mm ML) – **Oaxaca** • Bahía La Entrega; 15°44′35″N, 096°07′44″W; 5 m; 16 Jan. 2016; O. Valencia leg.; coral reef, scuba; UMAR-CEPHA 1161 (1 juvenile, 9.2 mm ML) • Bahía La India, Huatulco National Park; 15°40′47″N, 096°07′44″W; 5 m; 04 Dec. 2016; O. Valencia leg.; coral reef, scuba; UMAR-CEPHA 1162 (1 ♀, 16.8 mm LM) • El Faro, Puerto Ángel; 15°39′59″N, 096°29′35″W; 10 m; 18 Jan. 2016; artisanal fishermen leg.; rocky shores, free diving; UMAR-CEPHA 1163–1162 (2 ♂, 14.4, 19.5 mm ML).

Identification. A small octopus; ML usually <100 mm. Arms thin, 3–4× ML. Longest arms moderate to long, typically 3.0–4.5× ML, robust (AWI 15.9–20.4–26.5 %). Lateral arms longest 2>3>4>1 or 2>3>1>4 or 3>2>1>4. Hectocotylized arm with ~80–110 suckers; 1 or 2 conspicuously enlarged suckers present on all but ventral arms of mature males. Ligula well developed, elongate, conical, with distinct groove, and 10% of hectocotylized arm. Funnel length moderate, ~35% ML (FLI 16.1–52.9%), free portion funnel length 29.6% (FFLI 17.8–40.7%). Paleal aperture index 61.3% ML (API 39.4–74.2%). Mantle width index 81.3% (MWI 57.3–104.6%). Gills with 11 or 12 lamellae per demibranch.

Presence of specific characters: skin texture of patch and groove system with small or round patches; four primary papillae in a diamond pattern on the dorsal mantle; one large papilla on the mid-posterior dorsal mantle and one over each eye (Fig. 2A, B). Webs of moderate depth, web formula ABECD or ABEDC or AEBDC (Table 1).

The internal anatomy has not been completely described. We include for the first time a description of the digestive tract. A marked separation was observed between the two indistinct posterior salivary glands. Anterior salivary glands short, 33% of ML; posterior salivary glands 65.7% of ML. Digestive gland ovoid, with a weak iridescent sheen. Ink sac well developed,

Table 1. *"Octopus" rubescens*. Measurements and counts of preserved organisms. TL = total length; DML = dorsal mantle length; VML = ventral mantle length; MWI = mantle width index; HLI = head length index; HWI = head width index; EDI = eye diameter index; HALI = hectocotylized length; FLI = funnel length index; FFLI = free funnel length index; API = paleal aperture index; WDI = web depth index; AF = arm formula; GL = gill counts, do not include terminal lamella. Juv, juvenile; Mich = Michoacán; Rev = Revillagigedo Archipelago.

Location	El Faro Oaxaca	La Entrega Oaxaca	La India Oaxaca	La Privada Mich	La Privada Mich	La Privada Mich	Isla Socorro Rev	Isla Socorro Rev	Isla Socorro Rev	Isla Socorro Rev	Isla Socorro Rev
Date	18/01/2016	16/01/2016	04/12/2016	25/02/2016	25/02/2016	24/02/2016	15/12/2015	15/12/2015	15/12/2015	15/12/2015	15/12/2015
Sex	♂	Juvenile	♀	Juvenile	Juvenile	♂	♀	♀	♀	♀	♀
W	5.4	1.8	18.1			15.7	15.0	17.2	1.5	4.3	34.0
TL	72.1	53.1	148.2	44.3	20.5	122.2	106.2	122.2	46.9	72.8	160.2
DML	14.4	9.2	16.8	9.6	5.6	21.2	20.2	25.0	13.3	19.1	31.6
VML	11.4	9.3	16.5	8.2	5.1	18.2	20.2	20.2	8.4	14.0	26.2
MWI	104.6	98.9	91.1	92.4	98.2	91.3	66.9	74.2	57.3	58.5	70.4
HLI	45.5	53.1	51.6	56.4	54.4	52.8	40.0	35.8	35.8	35.6	32.1
HWI	100.4	100.5	102.6	101.0	109.5	82.0	73.9	71.0	67.1	61.3	68.1
EDI	26.6	19.8	49.7	54.5	48.2	52.4	28.2	21.3	28.9	34.4	29.3	15.3
FLI	52.9	24.2	46.6	44.1	37.2	28.5	31.7	32.4	24.7	45.7	35.9	16.1
FFLI	35.1	26.0	30.0	35.1	30.3	17.8	40.7	38.2	29.6	20.4	25.7	26.3
API	74.2	58.0	62.2	65.4	66.8	73.3	70.2	53.6	71.1	39.4	55.1	45.7
HALI		301.0					436.1	376.2				
WD	AEDBC	ABCED	AEDBC	BEDAC	ABCDE	ABECD	ABEDC	AEBDC	ABEDC	ABCED	AEDBC	ABEDC
AF	2>3>1>4	3>2>1>4	2>3>1>4	3>2>1>4	2>3>1>4	4>2>1>3	2>3>1>4	2>3>1>4	2>3>1>4	3>2>1>4	3>2>1>4	2>3>4>1
GL	11	11	11	12	12	11	12	12	12	12	11	12

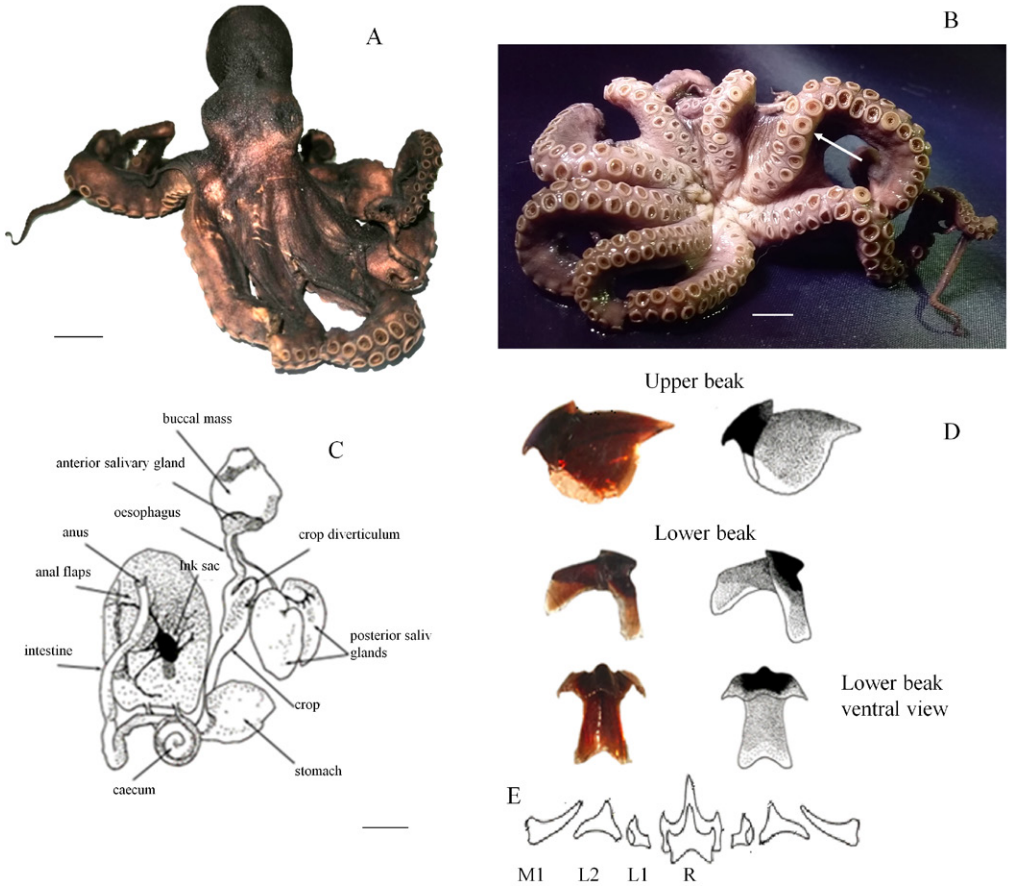

Figure 2. "*Octopus*" *rubescens*. **A.** Male (DLM = 21.2 mm), dorsal view. **B.** Oral view, scale 10 mm. **C.** Digestive tract. **D.** Beak, lateral view. **F.** Radula: R, radular tooth; L1 and L2, lateral teeth; M1, first marginal tooth. Arrow, arm 3 with enlarged suckers. Scale bars: A, B = 50 mm; C = 20 mm.

partly embedded in ventral surface of digestive gland. Anal flaps present and discrete. Esophagus straight; intestine muscular; caecum with 1.5 coils, distinctly striated (Fig. 2C).

Beaks: upper beak with a short, hooked rostrum; lower beak with narrow hood and lateral walls flared (Fig. 2D–F). Radula with seven teeth and two marginal plates per row; rachidian tooth with two moderate cusps, one each side (Fig. 2G).

"*Octopus*" *rubescens* (Fig. 3) has very distinctive characters that separate it from its congeneric species distributed along the Pacific coast of Latin America: "*O.*" *bimaculatus*, "*O.*" *hubbsorum*, "*O.*" *mimus*, and "*O.*" *oculifer*. "*Octopus*" *rubescens* can be distinguished from other octopuses present in the study area by its size and other morphological characteristics (Table 2), in addition to the following: a patch and groove skin texture with small, round patches; four primary papillae in a diamond pattern on the dorsal mantle; and one large papilla on the mid-posterior dorsal mantle and one over each eye. It is considerably smaller than congeneric species in the region: the ML of "*O.*" *rubescens* is 100 mm, vs. 220 mm in "*O.*" *hubbsorum* and 200 mm in "*O.*" *bimaculatus*. Gill lamellae number 11–13 in "*O.*" *rubescens*, vs. 9–11 in "*O.*" *hubbsorum* and 8–10 in "*O.*" *bimaculatus*. Ocelli are lacking in "*O.*" *rubescens*.

Figure 3. "*Octopus*" *rubescens*, female (DLM = 16.77 mm), Bahia La India, Huatulco National Park, México. Photo: Virgilio Antonio.

Discussion

While the taxonomic status of "*Octopus*" *rubescens* is currently being reviewed, this species has provisionally

Table 2. Morphological comparison of "*Octopus*" *rubescens* with other octopuses known to occur in waters in the Pacific Latin America Pacific Latin America (Norman et al. 2004).

Species	*"O." rubescens*	*"O." rubescens*	*"O." hubbsorum*	*"O." bimaculatus*	*"O." bimaculoides*	*"O." mimus*	*"O." oculifer*
Data source	Hochberg 1997	This study	Berry 1953	Verril 1883	Pickford and McConnaughey 1949	Gould 1852	Hoyle, 1904
Type locality	Gulf of California, Mexico north to Gulf of Alaska	Tropical Pacific	Gulf of California, south to Oaxaca	Also reported in Mexico from the head of the Gulf of California. Southern limits unknown	Northeast Pacific, on the Pacific coast of the Baja California Peninsula, Mexico	Southeast Pacific, along east coast of South America from northern Peru to Valparaiso, Chile	Galapagos Archipelago
DML (mm)	100	31.6	220	200	85	190	120
TL (mm)	250	160	>1000	1100	500	1200	420
Arm length (× LM)	3.5–4.5	3–4	3–4	4–5	3–3.5	4–6	2
Arm formula	2>3>4>1	2>3>4>1 or 2>3>1>4 or 3>2>1>4	4>2>4>1	2>3>4>1	3>2>4>1	2>3>4>1	2>3>4>1
Web depth (%)	20–30	20	30	28	25	18–27	22–27
Gill lamellae	11–13	11–12	9–11	8–10	8–10	7–8	8–10
Suckers hectocotylized arm	80–110	65–101	~140	134–157	102–116		~180
Ligula	Well developed, elongate and conical, with distinct groove, 8–11% of arm length		Tiny, around 1–2% of arm length	Tiny, 1.2–2.8% of arm length	Tiny, 1.4–2.3% of arm length	Tiny, 0.7–1.8% of arm length	Tiny, 0.7–1.4% of arm length
Calamus	Small, ~20% of ligula length		Small, ~20% of ligula length	Small to moderate size, 40–60% of ligula	Moderate size, 40–50% of ligula length	Large, 30–60% of ligula length	Small
Ocelli	No	No	No	Yes	Yes	No	Yes
Sculpture Skin texture	Patch and groove system, patches small, round or circular; 4 primary papillae in diamond pattern on dorsal mantle, and 1 large papilla on mid-posterior mantle	Patch and groove system, patches small, round or circular; 1 large papilla on mid posterior mantle	Patch and groove system; 4 large papillae in diamond pattern on dorsal mantle	Patch and groove with small circular patches; 4 large primary papillae in diamond arrangement on dorsal mantle	Skin densely covered with papillae ("granular"); 4 large primary papillae in diamond arrangement on dorsal mantle	Skin rugose, densely covered in inflated patches, numerous papillae on dorsal mantle	Skin texture of round patches of various sizes; 4 large papillae in diamond on dorsal mantle
Supraocular papillae	1	1	1–2	1–2		1–2	No
Depth (m)	0–300	0–10	0–30	0–50	Intertidal zone to at least 20 m	0–30	0-50
Fishing importance	Occasionally as bycatch in inshore ground fish trawls	Occasionally in artisanal fishing	Artisanal fishing	Small-scale harvests	Small-scale	commercial fisheries	Small-scale

been placed in the genus *Octopus* (Norman et al. 2014). However, this species taxonomically fits in the genus *Octopus sensu stricto* (Norman et al. 2014) on account of the following: skin papillate; arms 3–5× ML; males with one or more enlarged suckers on all or some arms; formula typically 2>3>4>1 or 3>2>4>1; suckers large; skin with distinct patch; eyes not protruding; spermatheca present; copulatory organ with distinct ligula and calamus.

Our material fits well with the original description of the species by Berry 1953 and provided by Hochberg (1997). All measurements, counts and the patch and groove system of skin texture in our specimens match the descriptions of this species and are similar to those reported in records from the Gulf of California by Hochberg (1997). It is important include both morphological characteristics and quantitative attributes of octopuses.

Here, we record "*O.*" *rubescens* for the first time in Mexican tropical Pacific waters. Juveniles and mature females were recorded in tide pools. Huatulco, Oaxaca is now the southernmost limit of the geographic distribution of this species. The two mature males captured by fishermen suggest that this species inhabits the central coast of Oaxaca and that "*O.*" *rubescens* can be part of artisanal catches of octopus. In this area, octopus fishing is artisanal and is carried out in shallow waters. "*Octopus*" *hubbsorum* is the most common octopus (Alejo-Plata et al. 2009), and "*O.*" *bimaculatus* has occasionally been observed in the captures (Alejo-Plata et al. 2014).

Thus, our new records are important documentation showing changes in the geographic ranges of organisms in the tropical Mexican Pacific. The geographic distribution of "*O.*" *rubescens* is extended from southern part of the Gulf of California to Puerto Ángel, Oaxaca, Mexico, approximately 2118 km southward. The five localities from the Pacific coast of Mexico are evidence that this species has established a population in tropical waters. However, more data is required to fully understand its ecology and distribution of "*O.*" *rubescens* in the Mexican tropical Pacific. Our study reflects the limited knowledge of octopuses in the region and suggests the need for increased sampling effort.

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Authors' Contributions

Conceptualization: MCAP. Formal analysis: MCAP. Funding acquisition: MCAP. Resources: MCAP, OVM**.** Formal analysis: MARP, OVM, OI. Visualization: MARP, OI. Writing review & editing: MCAP, MARP, OVM, OI.

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