Occurrence of the Earthworm *Drawida barwelli* (Beddard, 1886) in Taiwan

Huei-Ping Shen

Endemic Species Research Institute, Jiji, Nantou, Taiwan

Corresponding author: shenhp@tesri.gov.tw

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Abstract

This paper describes the moniligastrid earthworm *Drawida barwelli* (Beddard, 1886) as a new record from Taiwan. It is a small earthworm originated from Southeast Asia. It was collected from coastal plains and hills below 1000 m in elevation in central, southern and Hualien and Taitung (including Lanyu) counties in eastern Taiwan, and has never been found in northern Taiwan. Its occurrence in Taiwan reported herein constitutes the island as the northern extremity of the distributional range of this peregrine species.

Key words: *Drawida barwelli*, earthworm, Taiwan

台灣新紀錄種蚯蚓巴氏杜拉蚓 *Drawida barwelli* (Beddard, 1886)

沈慧萍

行政院農業委員會特有生物研究保育中心　南投縣集集鎮民生東路 1 號

通訊作者：shenhp@tesri.gov.tw

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摘要

本文描述一原產於東南亞之新紀錄種蚯蚓巴氏杜拉蚓 *Drawida barwelli* (Beddard, 1886)。其爲小型蚯蚓，屬於鏈胃蚓科 (Moniligastridae) 杜拉蚓屬 (*Drawida*)，在台灣中南部及東部花東地區(包括蘭嶼)海拔一千公尺以下的海岸平原至丘陵地帶均有分布，北台灣則未曾有採集紀錄，顯示台灣應爲此廣布種蚯蚓分布範圍之北界。

關鍵詞：巴氏杜拉蚓、蚯蚓、台灣

Introduction

Drawida barwelli was first described by Beddard (1886) as *Moniligaster barwelli* based on the examination of about 20 specimens obtained by Mr. H. E. Barwell from the neighborhood of Manila, Philippines. According to the original description (Beddard 1886), *Dr. barwelli* is a small earthworm not more than 1.5 inch (about 38 mm) in length. It has thin, delicate and much coiled sperm ducts (vasa deferentia). The so-called copulatory pouches in the 8th segment in the original description were later corrected by Beddard (1887) as spermathecae. Therefore, the spermatheca of *Dr. barwelli* is composed of a small, spherical ampulla and a long, slender, coiled and contorted spermathecal duct (Beddard 1886, Plate II, Fig. 5). Beddard (1886) also mentioned that "The only apertures that I could detect upon the surface of the body besides the mouth and anus were two oval slit-like orifices with tumid yellowish lips, which are the male generative orifices". However, Beddard (1888; 1891) provided further descriptions together with figures which differ from his original description: the sperm duct is simple, short and not twisted, and the spermathecal duct is simple and quite straight. The presence of dorsal pores was mentioned in Beddard (1891). Apparently, '*Moniligaster barwelli*' described in Beddard (1888; 1891) actually belongs to another species. When the structures of the sperm duct and spermathecal duct depicted in Beddard (1888; 1891) are compared with those of *Drawida beddardii* (Rosa, 1890) from Burma, they are not distinguishable (see Beddard 1888, Plate XII, Fig. 12 and Rosa 1890, Plate XII, Fig. 12). In addition, *Dr. beddardii* has dorsal pores (Rosa 1890). Later, Beddard (1893) describes *Moniligaster bahamensis* imported accidentally with plants from the Bahamas to Kew Gardens as a small and slender worm measuring about 25 mm in length. Beddard (1893) states that the sperm ducts are remarkably long and much convoluted in *bahamensis* but misstates that the sperm ducts are very short in both *barwelli* and *beddardii*. Moreover, the structure of spermatheca of *bahamensis* as shown in Beddard (1893, Plate XLV, Fig. 2) is akin to that of *barwelli* (Beddard 1886, Plate II, Fig. 5). It is obvious that Beddard (1888; 1891) mistook *Dr. beddardii* for *Dr. barwelli*, and then Beddard (1893) erected a junior synonym, *Dr. bahamensis*, of *Dr. barwelli*. Due to misidentification by Beddard (1888; 1891; 1893; 1895), *Dr. beddardii* has long been wrongly considered synonymous with *Dr. barwelli* (see Shen *et al*. 2015).

Blakemore (2010), Blakemore and Kupriyanova (2010) and Blakemore *et al*. (2014) synonymized *Drawida glabella* Chen, 1938 from Hainan Island with *Dr. barwelli*. However, body size, structures of spermatheca and male organs and presence or absence of dorsal pores of both species are distinctively different (Shen *et al*. 2018). Consequently, *Dr. glabella* is not synonymous with *Dr. barwelli* and should be recognized as a valid species.

A checklist of moniligastrids with *Desmogaster sinensis* Gates, 1930 and a total of 41 species and subspecies of *Drawida* from East Asia including China, Japan, Korea and far eastern Russia was provided by Blakemore *et al*. (2014). To date, *De. sinensis* and six species of *Drawida* were recorded from Taiwan and its adjacent islands. Except for *De. sinensis*, *Drawida koreana* Kobayashi, 1938, *Drawida beiganica* Shen and Chang, 2015 and *Drawida dongyinica* Shen and Chih, 2015 from Matsu, only three species, namely *Drawida japonica* (Michaelsen, 1892), *Drawida alishanensis* Shen and Chang, 2018 and *Drawida fenqihuensis* Shen and Chih, 2018, were reported from the island of Taiwan. *Dr. japonica* was first documented by Kobayashi (1939; 1940ab) from Hsinchu, northern Taiwan, and has never been found again from Taiwan or other adjacent islands for nearly 80 years. As to *Dr. alishanensis* and *Dr. fenqihuensis*, the finding of the two endemic earthworms at elevations of 1407–1661 m in the Alishan area, Chiayi County is the first time that new species of *Drawida* are discovered from the island of Taiwan (Shen *et al*. 2018).

Drawida barwelli is a peregrine earthworm and has been reported from the Philippines (Beddard 1886; Gates 1965), Singapore (Shen and Yeo 2005), Lombok, Indonesia (Michaelsen 1922), Pacific Islands (Michaelsen 1910a; Kobayashi 1941; Gates 1969; Easton 1984), Central America (Beddard 1893; Gates 1954; 1965; Easton 1984), and Australia (Blakemore 2010; Blakemore and Kupriyanova 2010). Its distributional range has been confounded with that of *Dr. beddardii* by Blakemore (2010), Blakemore and Kupriyanova (2010) and Blakemore *et al*. (2014) since the two species were wrongly synonymized by these authors. In Taiwan, *Dr. barwelli* was collected from coastal plains and hills below 1000 m in elevation in central, southern and Hualien and Taitung (including Lanyu) counties in eastern Taiwan, and has never been found in northern Taiwan though other species of *Drawida* were obtained (unpublished data). Furthermore, it is absent from the earthworm fauna of Kinmen (Chang *et al*. 2012), Matsu (Shen *et al*. 2015) and Japan (Blakemore 2012; Blakemore *et al*. 2014). *Drawida* cf. *barwelli* found in Korea (Blakemore *et al*. 2012; 2014) is a misidentification of *Drawida eda* Blakemore, 2010 (see Shen *et al*. 2018). Although Beddard (1893) received *Dr. barwelli* alive from Kew, this species is only found in hot greenhouses in Kew Gardens and has never been able to colonize the soils outside of the artificial environments in the UK (Sherlock 2012). Accordingly, its occurrence in Taiwan reported herein constitutes the island as the northernmost range of this species.

The following description is based on 126 preserved specimens deposited at the Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan.

Drawida barwelli (Beddard, 1886)

Moniligaster barwelli Beddard, 1886: 94; 1887: 678; 1895: 200 (part).

Drawida barwelli – Michaelsen, 1900: 116 (part); 1910a: 51; 1922: 6; Gates, 1937: 306; 1965: 87; Kobayashi, 1941: 391; Easton, 1984: 112 (part); Blakemore, 2010: 137 (part); Blakemore and Kupriyanova, 2010: 4 (part); Blakemore *et al*., 2014: 130 (part).

Moniligaster bahamensis Beddard, 1893: 690; 1895: 202.

Drawida bahamensis – Michaelsen, 1900: 118; Gates, 1954: 241; 1965: 85; 1969: 4.

Drawida japonicus bahamensis – Michaelsen, 1910b: 50.

Drawida sp. 3 Shen and Yeo, 2005: 30.

Materials examined.—One specimen collected on the 13 March 2000 along Road 20 (elevation 430 m), Jiasian, Kaohsiung County by C. F. Tsai, S. C. Tsai, H. S. Fang, S. T. Chang, T. J. Lin, H. P. Yang and H. P. Shen (coll. no. 2000-8); three specimens collected on the 16 April 2000 around the lighthouse (elevation 200 m), northwestern Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, H. P. Yang and H. P. Shen (coll. no. 2000-36); one specimen collected on the 16 April 2000 from the neighborhood area of the Green Grassland (elevation 42 m), southern Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, H. P. Yang and H. P. Shen (coll. no. 2000-38); one specimen collected on the 17 April 2000 around the weather station (elevation 324 m), central Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, S. T. Chang, H. P. Yang, Y. C. Chiu, S. L. Hsu, and H. P. Shen (coll. no. 2000-40); one specimen (amputated) collected on the 17 April 2000 from the valley around the Lung-men Bridge (elevation 18 m), southeastern Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, S. T. Chang, H. P. Yang, Y. C. Chiu, S. L. Hsu, and H. P. Shen (coll. no. 2000-42); three specimens collected on the 17 April 2000 from Yung-hsing Farm (elevation 13 m), southeastern Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, S. T. Chang, H. P. Yang, Y. C. Chiu, S. L. Hsu, and H. P. Shen (coll. no. 2000-43); one specimen collected on the 17 April 2000 from the neighborhood near the mouth of the Langtao Creek (elevation 8 m), northern Lanyu, Taitung County by C. F. Tsai, S. C. Tsai, H. S. Fang, S. T. Chang, H. P. Yang, Y. C. Chiu, S. L. Hsu, and H. P. Shen (coll. no. 2000-45); one specimen collected on the 12 September 2005 along Road 20 near Baiyun Temple (elevation 600 m), Jiasian, Kaohsiung County by H. P. Chen and H. S. Fang (coll. no. 2005-17); five specimens collected on the 15 September 2005 beside Danan Creek (elevation 170 m), Beinan, Taitung County by H. P. Chen, I. M. Hsiao and S. T. Chang (coll. no. 2005-37); one specimen collected on the 12 June 2007 from roadside ditches along Tienshen Temple toward Douliou (elevation 200 m), Huben Village, Linnei, Yunlin County by M. H. Chen (coll. no. 2007-23); one specimen collected on the 27 June 2007 from Sweet Gum trail (elevation 135 m) near Waihu Creek, Douliou, Yunlin County by S. T. Chang and Y. P. Li (coll. no. 2007-26); one specimen collected on the 27 June 2007

from the neighborhood of Hueichun Temple (elevation 140 m), Douliou, Yunlin County by S. T. Chang and Y. P. Li (coll. no. 2007-28); one specimen collected on the 29 June 2007 around Tienshen Temple (elevation 194 m), Huben Village, Linnei, Yunlin County by T. J. Lin and Y. P. Li (coll. no. 2007-34); two specimens collected on the 18 July 2007 from roadside slope along Fongshuhu South Creek (elevation 150–210 m) near the borders of Douliou and Linnei, Yunlin County by C. H. Chang, Y. H. Lin and T. J. Lin (coll. no. 2007-45); one specimen collected on the 18 July 2007 from Budhi Shrine of White Horse Mountain (elevation 130–144 m), Huben Village, Linnei, Yunlin County by C. H. Chang, Y. H. Lin and T. J. Lin (coll. no. 2007-47); five specimens collected on the 14 August 2007 around Tienshen Temple (elevation 194 m), Huben Village, Linnei, Yunlin County by C. H. Chang, Y. H. Lin and Y. P. Li (coll. no. 2007-52); one specimen collected on the 16 August 2007 from Budhi Shrine of White Horse Mountain (elevation 130–144 m), Huben Village, Linnei, Yunlin County by C. H. Chang, Y. H. Lin and Y. P. Li (coll. no. 2007-66); one specimen collected on the 11 September 2007 from Yuchin Valley (elevation 178–230 m) near the borders of Douliou, Yunlin County and Jhushan, Nantou County by T. J. Lin, Y. P. Li and H. I. Tsai (coll. no. 2007-72); one specimen collected on the 11 September 2007 beside Beishihkeng Creek (elevation 185–204 m), Douliou, Yunlin County by T. J. Lin, Y. P. Li and H. I. Tsai (coll. no. 2007-73); seven specimens collected on the 13 September 2007 from roadside ditches along Tienshen Temple toward Douliou (elevation 200 m), Huben Village, Linnei, Yunlin County by T. J. Lin, Y. P. Li and H. I. Tsai (coll. no. 2007-83); two specimens collected on the 13 September 2007 from roadside slope along Fongshuhu South Creek (elevation 150–210 m) near the borders of Douliou and Linnei, Yunlin County by T. J. Lin, Y. P. Li and H. I. Tsai (coll. no. 2007-85); three specimens collected on the 24 October 2007 around Tienshen Temple (elevation 194 m), Huben Village, Linnei, Yunlin County by T. J. Lin, Y. P. Li and C. H. Chang (coll. no. 2007-96); one specimen collected on the 30 October 2007 from Budhi Shrine of White Horse Mountain (elevation 130–144 m), Huben Village, Linnei, Yunlin County by T. J. Lin, Y. P. Li and C. H. Chang (coll. no. 2007-103); one specimen collected on the 11 December 2007 from Dakeng (elevation 214–290 m), Huben Village, Linnei, Yunlin County by T. J. Lin, Y. P. Li and C. H. Chang (coll. no. 2007-120); one specimen collected on the 4 March 2008 from Yuchin Valley (elevation 228 m) near the borders of Douliou, Yunlin County and Jhushan, Nantou County by T. J. Lin and Y. P. Li (coll. no. 2008-4); one specimen collected on the 12 July 2010 near Gaotai (elevation 245 m), Chenggung, Taitung County by H. P. Chen and C. I. Chang (coll. no. 2010-33); 13 specimens collected on the 13 July 2010 from Chihkoshan (elevation 249 m), Yuli, Hualien County by H. P. Chen and C. I. Chang (coll. no. 2010-35); one specimen collected on the 13 July 2010 near Coastal Mountains *Cycas*

taitungensis Nature Reserve (elevation 490 m), Taitung County by H. P. Chen and C. I. Chang (coll. no. 2010-40); seven specimens collected on the 14 July 2010 along Shantsungliao Road (elevation 373 m), Chihshang, Taitung County by H. P. Chen and C. I. Chang (coll. no. 2010-42); two specimens collected on the 18 October 2010 near Coastal Mountains *Cycas taitungensis* Nature Reserve (elevation 490 m), Taitung County by R. C. Jang, M. H. Chen and L. H. Chen (coll. no. 2010-59); three specimens collected on the 26 May 2011 along Walami trail (elevation 750–840 m), Jhuohsi, Hualien County by S. T. Chang, M. H. Chen and C. I. Chang (coll. no. 2011-12); two specimens collected on the 26 October 2011 along Ningpu Road (elevation 181 m), Ningpu Village, Changbin, Taitung County by H. P. Chen and C. I. Chang (coll. no. 2011-93); two specimens collected on the 26 October 2011 at Tzuchiang Bridge (elevation 133 m), Baliwan Village, Fongbin, Hualien County by H. P. Chen and C. I. Chang (coll. no. 2011-96); five specimens collected on the 27 October 2011 along Road 38-1 (elevation 238 m), Shoufeng, Hualien County by H. P. Chen and C. I. Chang (coll. no. 2011-100); one specimen collected on the 25 May 2016 near the epicenter of the 921 earthquake (elevation 786 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-17); two specimens collected on the 21 June 2016 around the memorial near the quake lake (elevation 602 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-23); five specimens collected on the 22 June 2016 around the giant stone observatory (elevation 730–740 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-28); ten specimens collected on the 22 June 2016 near the epicenter of the 921 earthquake (elevation 786 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-29); one specimen collected on the 20 July 2016 around the giant stone observatory (elevation 730–740 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-38); one specimen collected on the 16 August 2016 near the quake lake (elevation 585–602 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-42); two specimens collected on the 16 August 2016 around Shimen observatory (elevation 535 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-43); one specimen collected on the 17 August 2016 around the giant stone observatory (elevation 730–740 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-47); one specimen collected on the 18 October 2016 near Jiutsaihu Bridge (elevation 647 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-51); one specimen collected on the 19 October 2016 around the giant stone observatory (elevation 730–740 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-57); 18 specimens collected on the 19 October 2016 near the epicenter of the 921 earthquake (elevation 786 m), Guohsing, Nantou County by C. S. Huang and P. H. Lin (coll. no. 2016-58).

Description. － Length (clitellates) 25–44 mm, weight 0.02–0.07 g, diameter 1.35–2.23 mm. Segment number 89–119. Prostomium prolobous. Dorsal pores absent. Setae lumbricine (eight setae per segment), minute, closely paired. Clitellum X–XIII, indistinct, whiter than rest of the body, yellowish egg sacs visible through epidermis in the clitellar region. Spermathecal pores one pair in 7/8, in line with seta c, concealed in the intersegmental furrow, occasionally with a small papilla about 0.15 mm in diameter anterior to each pore. Male pores one pair on small, eversible penes across 10/11 (Fig. 1AB). Penes usually wholly concealed in retracted condition with anterior and posterior whitened pads around the secondary male apertures (Fig. 1C). Female pores minute, hardly visible, one pair on anterior margin of XII, each pore lateral to seta b (Fig. 1A). Preserved specimens unpigmented or with translucent pale skin.

Septa 5/6–8/9 thickened, 9/10 to posterior end thin. Gizzards large, three in XIV–XVI, white, shining. Hearts paired in VI–IX. Nephridia holoic. Testis sacs one pair, pear-shaped, each suspended on septum 9/10, about 0.52 mm in length and 0.42 mm in width. Sperm duct long, compact, heavily coiled into a tight ball of loops, with a short, slender, straight distal end connecting to male atrium on the penial chamber (Fig. 1D). Male atrium small, follicular, cotton-like, about 0.25 mm in length, attached to penial chamber. Penial chamber small, spherical, about 0.28 mm in diameter. One pair of follicular, yellowish ovisacs dorso-lateral on both sides of the digestive tract, occupying three to eight segments in XI–XVIII. Spermathecae one pair, both ampulla and spermathecal atrium posterior to septum 7/8. Ampulla small, spherical, about 0.2 mm in diameter, its duct long, slender, with three or four coils to join the spermathecal atrium (Fig. 1E). Spermathecal atrium small, spherical, about 0.15 mm in diameter. Accessory glands absent.

Remarks. － The characters of the specimen from Caroline Islands examined by Kobayashi (1941) agree mostly with the typical morphology of *Dr. barwelli* except the elongated-oval ampulla, absence of spermathecal atrium and placement of most of the sperm duct in segment IX rather than in X. Additionally, the two specimens from Fiji with much larger body size (length 66 mm, diameter 3–4 mm, 137–163 segments) and short spermathecal ducts and without spermathecal atrium documented by Easton (1984) should belong to some other species, or maybe a new species.

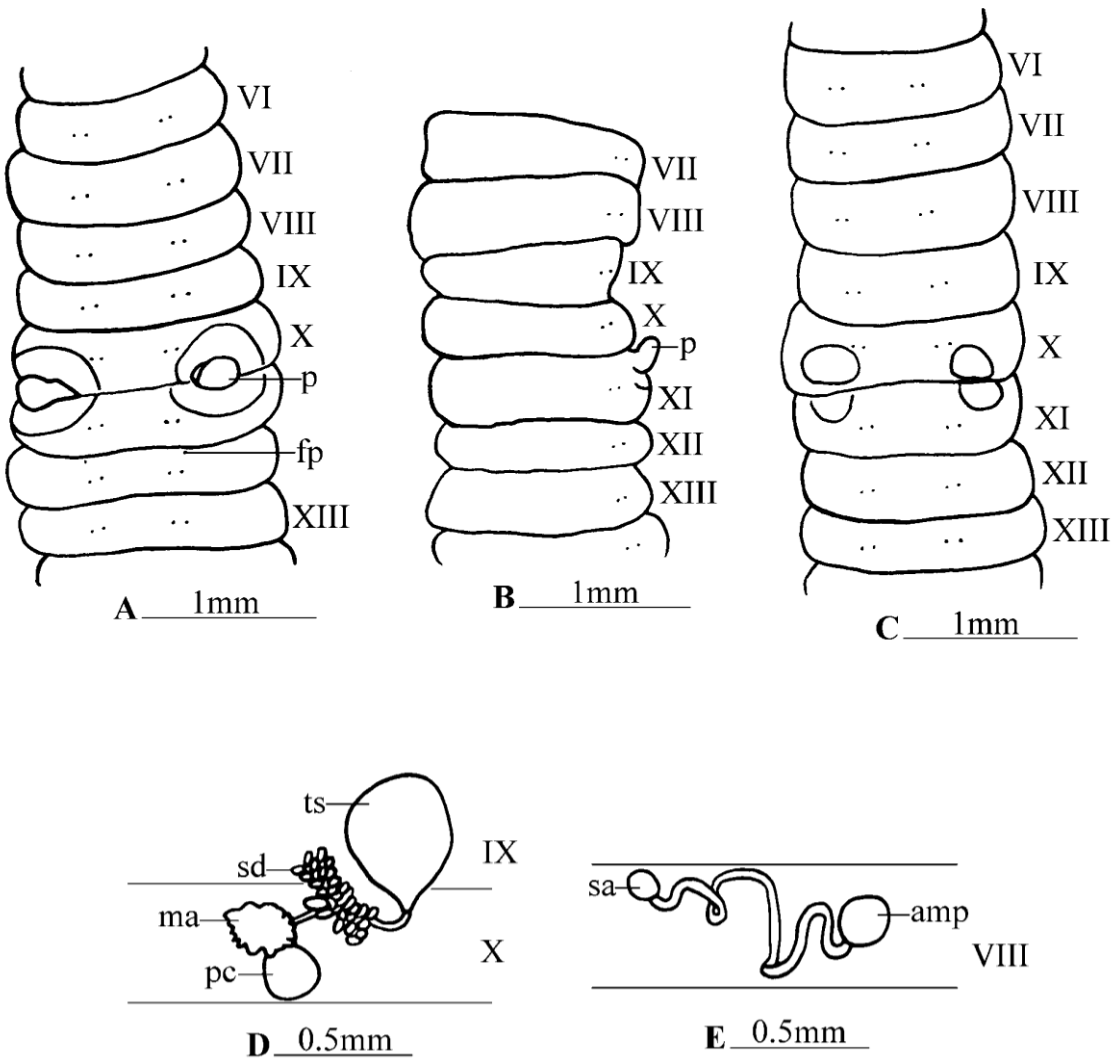

Fig. 1. *Drawida barwelli* (Beddard): A, ventral view of clitellar region (p, penis; fp, female pore); B, right-lateral view of clitellar region; C, ventral view of clitellar region; D, dorsal view of left testis sac (ts), sperm duct (sd), male atrium (ma) and penial chamber (pc); E, dorsal view of left spermatheca (amp, ampulla; sa, spermathecal atrium).

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