Range extension of two deep-sea nudibranchs, *Tritonia newfoundlandica* and *Doridoxa ingolfiana* (Mollusca: Gastropoda: Heterobranchia), in eastern Canada

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Penney, H.D., J.-F. Hamel, and A. Mercier. 2020. Range extension of two deep-sea nudibranchs, *Tritonia newfoundlandica* and *Doridoxa ingolfiana* (Mollusca: Gastropoda: Heterobranchia), in eastern Canada. Canadian Field-Naturalist 134(2): 165–170. https://doi.org/10.22621/v134i2.2443

**Abstract**

Deep-sea nudibranchs (Mollusca: Gastropoda: Heterobranchia) have rarely been reported from eastern Canada. Here we describe range extensions for two species found in the northwest Atlantic Ocean. *Tritonia newfoundlandica* Valdés, Murillo, McCarthy & Yedinak, 2017 was originally collected on the Flemish Cap off Newfoundland, Canada, and *Doridoxa ingolfiana* Bergh, 1899 was originally found off western Greenland with further records in Iceland, northern Norway, and southeastern Canada. We extend the northern range of *T. newfoundlandica* 1067 km along the eastern coast of North America and add occurrences of *D. ingolfiana* in the Labrador Sea, bridging a 2044 km gap between previous records in Greenland and southern Newfoundland. The latter species thus exhibits a continuous distribution from Svalbard, the Faroe Islands, Greenland, down to the southern tip of the Grand Banks in eastern Canada. *Tritonia newfoundlandica* was collected in its known depth range, whereas the depth distribution of *D. ingolfiana* was extended by 30 m to a maximum depth of 1375 m. Both species were collected with numerous nephtheid corals, suggesting that there may be a functional relationship, where the nudibranchs find refuge or food on them.

Key words: North Atlantic Ocean; Newfoundland and Labrador; sea slug; Tritoniidae; Doridoxidae; biodiversity; taxonomy; *Tritonia newfoundlandica*; *Doridoxa ingolfiana*

**Introduction**

Members of the dendronotid nudibranch family Tritoniidae (Menke, 1828) are grouped into 11 genera and over 80 species, many occurring worldwide. One of the most recently described species, *Tritonia newfoundlandica* Valdés, Murillo, McCarthy & Yedinak, 2017 (no common name) was originally collected on the Flemish Cap off Newfoundland, Canada, and *Doridoxa ingolfiana* Bergh, 1899 was originally found off western Greenland with further records in Iceland, northern Norway, and southeastern Newfoundland. The latter species thus exhibits a continuous distribution from Svalbard, the Faroe Islands, Greenland, down to the southern tip of the Grand Banks in eastern Canada. *Tritonia newfoundlandica* was collected in its known depth range, whereas the depth distribution of *D. ingolfiana* was extended by 30 m to a maximum depth of 1375 m. Both species were collected with numerous nephtheid corals, suggesting that there may be a functional relationship, where the nudibranchs find refuge or food on them.

Individuals of *D. bentalis* were collected in deep waters (~2300 m) of the southern Atlantic Ocean off South Africa (Barnard 1963). The two original specimens of *D. ingolfiana* were collected off western Greenland in the North Atlantic Ocean during the Danish Ingolf Expedition over a century ago (Bergh 1900). Bergh named the larger specimen *D. ingolfiana* and considered the smaller one a “variant”. In 1970, another specimen was collected south of Greenland (Just et al. 1985). The third species, *D. walteri*, occurs in Norwegian, Russian, and adjacent waters. It was originally placed in the genus *Dermatobranchus*, but was recently moved to *Doridoxa* (Kantor and Syzoev 2006). Very little is known about its biology.

We add new records of *T. newfoundlandica* and *D. ingolfiana* from the continental slope of Labrador and the Grand Banks of Newfoundland (eastern Canada).
Methods

During scientific expeditions led by Fisheries and Oceans Canada, multispecies surveys were conducted annually on CCGS Teleost between September and December, 2006–2015 (see Power et al. 2016 and references therein). Surveys followed a random stratified sampling design, where each set deployed a Campelen 1800 trawl that was towed for 15 min (~1.4 km), with the net opening and closing at depth (~500–1500 m). Although the trawl was not designed to target small benthic organisms, several from a variety of phyla, including gastropod molluscs, were collected as bycatch. Species collected in the same trawls (e.g., sponges, corals) were also noted. Some of the nudibranchs collected in these surveys (n = 5) were preserved in 4% formalin, whereas samples from 2011 and 2013 were frozen at −20°C. Three other individuals were kept alive for study.

The preserved specimens were examined under a dissecting microscope (M205A, Leica Microsystems, Singapore) and photographed (microscope camera DFC7000T, Leica Microsystems, Wetzlar, Germany). Identification was based on colour, size, general appearance, and more specific external morphological characteristics in preserved specimens (including the penis, secondary gills, rhinophores, renal and anal pores, and dorsum), as well as on some internal characters, namely the radula, using descriptions from Valdés et al. (2017) for T. newfoundlandica and from Schrödl et al. (2001) and Valdés et al. (2017) for D. ingolfiana. Voucher specimens of T. newfoundlandica (n = 1) and D. ingolfiana (n = 1) were deposited at the Canadian Museum of Nature, Ottawa (catalog numbers CMNML 2020-0001 and CMNML 2020-0002, respectively). The remaining preserved specimens were kept and stored in the Mercier Lab collection, Ocean Sciences Centre, Memorial University (Newfoundland and Labrador, Canada).

A literature search was conducted to locate all records of T. newfoundlandica and D. ingolfiana. Data on geographic distributions and depth ranges were summarized. Records were mapped using ggplot2 in R (v. 4.0.2; R Development Core Team 2015).

Results and Discussion

Of the 231 deep-sea trawls conducted between the northern Labrador coast and the southern section of the Grand Banks, 10 sets contained nudibranchs (from depths ranging between 930 and 1375 m; Table 1). Several of the nudibranch specimens were collected on or together with bathyal nephtheid corals, i.e., Duva florida (Flowery Carnation Coral), Gersemia fruticosa (Hedge Carnation Coral), and Drifja glomerata (Orb Carnation Coral). Garcia-Matucheski and Muniaín (2011) showed evidence of Tritonia species feeding on nephtheid corals (including G. fruticosa), which could support the hypothesis that T. newfoundlandica and D. ingolfiana also feed on them.

Specimens of T. newfoundlandica (n = 5) were black (Figure 1a–e) with 10 pairs of reddish-brown (on live specimens) secondary gills on the fringes of the dorsal body wall (Figure 1a,b), which faded to yellowish brown after preservation. Preserved specimens had an elongate body, a rounded anterior end, and a pointed posterior end (Figure 1a) as described by Valdés et al. (2017). Specimens had perforilated rhinophores with six branched vertical lamellae and rhinophoral sheaths (Figure 1a,c,d), and an undivided oral veil bearing 10 simple, tentacular processes (Figure 1d). The right, lateral side of the body had a renal and anal pore, as well as the genital opening with a penis (finishing like an arrow or looking short and straight) visible in some specimens (Figure 1a,c). The penis features provided key support for the identification of this species, as mentioned by Valdés et al. (2017). The dorsum was smooth and lacking tubercles (Figure 1a). Total body lengths (mean 37 mm, range 26–45 mm) were within the previously documented range (20–60 mm; Valdés et al. 2017). One specimen of T. newfoundlandica possessed a well-developed whitish female gland complex, which was visible through the body wall (Figure 1e).

Doridoxa ingolfiana (n = 7) were ovate with a broader anterior end (Figure 1f,g). They had perforilated rhinophores with sheaths (Figure 1f), and the genital openings, anal pore, and renal pore were exclusively on the right side of the body (Figure 1h). The penis was large, wide, smooth, had a general mushroom-like appearance at the tip, and was the same colour as the rest of the body (Figure 1g,h). This species did not exhibit oral veil papillae or secondary gills, consistent with descriptions by Schrödl et al. (2001) and Valdés et al. (2017). Although most of the specimens had papillae on the dorsum, one did not (Figure 1f); this is perhaps an artifact of long-term preservation. Schrödl et al. (2001) noted that papillae were occasionally lacking. The anal and renal pores were located posteriorly on the right side of the body (Figure 1h), as mentioned by Valdés et al. (2017). One specimen, at 39 mm total length, exceeded the previously reported maximum of 30 mm for all other specimens (Table 1). The colours of the current individuals were also lighter (beige, yellowish, or light pink) than the deep reddish brown described in Valdés et al. (2017). Likewise, the specimens found in Norway (Ringvold 2008; Evertsen and Bakken 2013) showed similar light-yellow colours. This suggests that this species displays colour variations that may be genetic or phenotypically plastic, based on environment or diet.

These new records extend the geographic distri-
### Table 1. Specimen and observational reports of *Tritonia newfoundlandica* and *Doridoxa ingolfiana*.

| Report     | Date         | Location       | Latitude, °N | Longitude, °W | Depth, m | n | Total length, mm | Source                  |
|------------|--------------|----------------|--------------|---------------|----------|---|------------------|-------------------------|
| *T. newfoundlandica* |             |                |              |               |          |   |                  |                         |
| Existing   | 26 June 2007 | Off NFL        | 46.4487      | 44.2460 W     | 492–538  | 1 | 38               | Valdés et al. 2017      |
|            | 29 June 2007 | Off NFL        | 46.7468      | 43.8828 W     | 480–471  | 2 | 45–60            | Valdés et al. 2017      |
|            | 3 July 2007  | Off NFL        | 48.0260      | 43.2692 W     | 596–599  | 1 | 51               | Valdés et al. 2017      |
|            | 17 July 2007 | Off NFL        | 46.8870      | 42.6087 W     | 1242–1245| 3 | 30–49            | Valdés et al. 2017      |
|            | 17 July 2007 | Off NFL        | 46.8873      | 42.5118 W     | 1083–1094| 6 | 26–39            | Valdés et al. 2017      |
|            | 17 July 2007 | Off NFL        | 47.0463      | 42.3430 W     | 759–764  | 1 | 47               | Valdés et al. 2017      |
|            | 5 Aug. 2008  | Off NFL        | 46.7150      | 45.0680 W     | 1232     | 2 | 26–27            | Valdés et al. 2017      |
|            | 5 June 2009  | Off NFL        | 48.0005      | 42.2393 W     | 1554–1607| 1 | 50               | Valdés et al. 2017      |
|            | 14 June 2009 | Off NFL        | 47.1643      | 42.5331 W     | 1132–1137| 4 | 34–42            | Valdés et al. 2017      |
|            | 15 June 2009 | Off NFL        | 47.0722      | 42.5509 W     | 1113–1122| 11| 30–37            | Valdés et al. 2017      |
|            | 16 June 2009 | Off NFL        | 46.8461      | 42.2824 W     | 870–871  | 2 | 26–35            | Valdés et al. 2017      |
|            | 17 June 2009 | Off NFL        | 46.8400      | 42.3596 W     | 856–943  | 2 | 34–40            | Valdés et al. 2017      |
|            | 18 June 2009 | Off NFL        | 46.7749      | 42.1349 W     | 1108–1127| 18| 23–38            | Valdés et al. 2017      |
|            | 19 June 2009 | Off NFL        | 46.6942      | 42.0314 W     | 1104–1112| 3 | 30–35            | Valdés et al. 2017      |
|            | 11 Aug. 2011 | Svalbard       | 78.5672      | 9.0692 E      | 578      | 2 | 20–30            | Zakharov and Jørgensen 2017 |
|            | 1 Sept. 2014 | Svalbard       | 78.5853      | 9.1353 E      | 510–521  | 3 | 20–30            | Zakharov and Jørgensen 2017 |
| New        | Oct. 2007    | East of NFL    | 45.9005      | 56.3620 W     | 930      | 1 | 45               | Our study*               |
|            | Nov. 2008    | Off Labrador   | 51.6141      | 50.7598 W     | 1324     | 1 | 35               | Our study                |
|            | Nov. 2009    | Off Labrador   | 56.4581      | 55.8019 W     | 1212     | 1 | 26               | Our study                |
|            | Sept. 2010   | Off Labrador   | 52.7167      | 52.2333 W     | 1111     | 1 | 38               | Our study                |
|            | Dec. 2014    | Off Labrador   | 57.6240      | 56.6186 W     | 1198     | 1 | 41               | Our study                |
| *D. ingolfiana* |           |                |              |               |          |   |                  |                         |
| Existing   | 12 June 2006 | Off NFL        | 43.0807      | 50.9988 W     | 290–300  | 1 | 26               | Valdés et al. 2017      |
|            | 19 June 2007 | Off NFL        | 45.8137      | 47.7428 W     | 119–120  | 1 | 23               | Valdés et al. 2017      |
|            | 29 June 2007 | Off NFL        | 46.7468      | 43.8828 W     | 471–480  | 2 | 25–27            | Valdés et al. 2017      |
|            | 17 July 2007 | Off NFL        | 46.8873      | 42.5118 W     | 1083–1094| 2 | 15–27            | Valdés et al. 2017      |
|            | 9 Aug. 2007  | Off NFL        | 46.0690      | 45.0008 W     | 1357–1358| 2 | 28–30            | Valdés et al. 2017      |
|            | 10 Aug. 2008 | Off NFL        | 46.1588      | 47.9140 W     | 110–114  | 1 | 18               | Valdés et al. 2017      |
|            | 18 June 2009 | Off NFL        | 46.7749      | 42.1349 W     | 1108–1127| 2 | 11–23            | Valdés et al. 2017      |
|            | N/A          | Faroe Islands  | 62.4987      | 6.3869 W      | 603      | 1 | N/A              | Sneli et al. 2005       |
|            | N/A          | W. Greenland   | 65.2833      | 53.7167 W     | 100      | 1 | 12               | Bergh 1899              |
|            | 21 Oct. 2005 | N. Norway      | 69.3762      | 15.7306 E     | 881–907  | 1 | 11               | Evertsen and Bakken 2013 |
|            | 5 Oct. 2005  | N. Norway      | 70.1183      | 17.1138 E     | 493–501  | 1 | 7                | Evertsen and Bakken 2013 |
| New        | Nov. 2006    | South of NFL   | 51.2500      | 41.1167 W     | 1250     | 1 | 22               | Our study†               |
|            | Dec. 2006    | South of NFL   | 51.0167      | 41.2667 W     | 1375     | 2 | 31–39            | Our study               |
|            | Nov. 2009    | Off Labrador   | 56.4581      | 55.8019 W     | 1212     | 1 | 19               | Our study               |
|            | Nov. 2012    | Off Labrador   | 54.9745      | 54.6517 W     | 960      | 2 | 18–24            | Our study               |
|            | Nov. 2015    | Off Labrador   | 52.3791      | 52.4372 W     | 1002     | 1 | 30               | Our study               |

Note: N/A = not available, NFL = Newfoundland, Canada.
*Voucher specimen at Canadian Museum of Nature: CMNML 2020-0001.
†Voucher specimen at Canadian Museum of Nature: CMNML 2020-0002.

Specimen and observational reports of *Tritonia newfoundlandica* (Figure 2a) and *Doridoxa ingolfiana* (Figure 2b). The North American range of *T. newfoundlandica* is extended by 9.6° (1067 km north) into the Labrador Sea. *Doridoxa ingolfiana* has historically been reported south of Newfoundland (Valdés et al. 2017) and off western Greenland (Schrödl et al. 2020).
The current samples demonstrate that the range of *D. ingolfiana* is likely continuous from at least Greenland to southern Newfoundland and extend the species maximum depth to 1375 m.

Recent work on other Cladobranchia nudibranchs in the genera *Coryphella*, *Flabellina* (Korshunova et al. 2017a), and *Zeusia* (Korshunova et al. 2017b) has revealed cryptic species in each genus. Our study suggests that the distribution of both species is extensive. Consequently, future work should examine genetic differences across latitudes for both *T. newfoundlandica* and *D. ingolfiana* to determine population structure, connectivity, and perhaps assess whether colour and morphological differences may reflect the presence of cryptic species, as already suggested in the *Tritonia* genus by Valdés et al. (2018).

**Author Contributions**

Writing – Original Draft: H.D.P. and J.-F.H.; Writing – Review & Editing: H.D.P., J.-F.H., and A.M.; Conceptualization: J.-F.H. and A.M.; Investigation: H.D.P. and J.-F.H.; Methodology: H.D.P. and J.-F.H.; Formal Analysis: H.D.P. and J.-F.H.; Funding Acquisition: A.M.

**Acknowledgements**

We thank the technicians of Fisheries and Oceans Canada as well as the crew of CCGS *Teleost* for their help during these benthic surveys and, more precisely, Philip Sargent for the collection of some nudibranchs. Thanks also to two anonymous reviewers for comments on an earlier version of the manuscript. This research was supported by grants from the Canada Foundation for Innovation and the Natural Sciences and Engineering Research Council of Canada to A.M.

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**Figure 2.** Map of existing and new records of a. *Tritonia newfoundlandica* and b. *Doridoxa ingolfiana.*
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Received 17 February 2020
Accepted 29 July 2020
Associate Editor: D.F. McAlpine