



## Two new Salamanders of the genus *Onychodactylus* from Eastern Honshu, Japan (Amphibia, Caudata, Hynobiidae)

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### Abstract

We describe two new species of hynobiid salamanders in the genus *Onychodactylus* from eastern Honshu, Japan, based on the morphological and genetic evidence. *Onychodactylus intermedius* sp. nov. is distributed in southern part of Tohoku District and northern Ibaraki and Niigata Prefectures, and was previously reported as S-Tohoku group. *Onychodactylus intermedius* belongs to the *O. japonicus* species complex, and differs from the other congeners in having relatively long tail, narrow head, short snout, 18 presacral vertebrae, and distinctly curved vomerine tooth series without gap. *Onychodactylus fuscus* sp. nov. is known from only four localities in Fukushima and Niigata Prefectures of Tohoku and Hokuriku Districts. It also belongs to the *O. japonicus* complex, but lacks the dorsal stripe, which is a diagnostic character of the species complex. In other characteristics, *O. fuscus* differs from the other congeners in having comparatively long tail, wide head and internarial space, shallowly curved vomerine tooth series with gap, and relatively few vomerine teeth. Both species described here breed in winter. Phylogenetically, the two new species are closely related to each other, forming a well-supported clade with *O. tsukubaensis* as their sister species. *Onychodactylus intermedius* sp. nov. is known to be parapatric with *O. japonicus* and *O. nipponoborealis* without hybridization, whereas *O. fuscus* sp. nov. is sympatric with *O. japonicus* at least in a single known locality, and analysis of microsatellite loci indicates they are reproductively isolated.

**Key words:** *Onychodactylus intermedius*, *Onychodactylus fuscus*, salamander, morphology, taxonomy, Eastern Honshu, Japan

### Introduction

Clawed salamanders of the genus *Onychodactylus* are a group of hynobiid salamanders endemic to northeast Asia, which is known as the sister lineage to the rest of the family Hynobiidae (Zhang *et al.* 2008). This genus was traditionally considered to contain only two species, *O. japonicus* (Houttuyn) from Japan and *O. fischeri* (Boulenger) from Russian Far East, northeast China, and Korean Peninsula (Sato 1943; Nakamura & Uéno 1963; Kuzmin 1995). However, recent genetic studies (Yoshikawa *et al.* 2008, 2010a, 2010b, 2012) and subsequent taxonomic revisions (Poyarkov *et al.* 2012; Yoshikawa & Matsui 2013; Yoshikawa *et al.* 2013) added six species to this genus, by separating three species from *O. fischeri* sensu lato (*O. koreanus* Min, Poyarkov & Vieites, *O. zhangyapingi* Che, Poyarkov, Li & Yan, and *O. zhaoermii* Che, Poyarkov & Yan), and three species from *O. japonicus* sensu lato (*O. nipponoborealis* Kuro-o, Poyarkov & Vieites, *O. tsukubaensis* Yoshikawa & Matsui, *O. kinneburii* Yoshikawa, Matsui, Tanabe & Okayama). However, of the six cryptic species recognized by Yoshikawa *et al.* (2008, 2010a), two (southern Tohoku [S-Tohoku] and Kinki groups) remained undescribed.

The S-Tohoku group was recognized in the previous genetic studies based on mtDNA and allozymes (Yoshikawa *et al.* 2008, 2010a, 2012), and was reported to be a sister taxon of *O. tsukubaensis* from central Kanto District of eastern Honshu. The S-Tohoku group is distributed in southern part of Tohoku District and adjacent northern parts of Ibaraki Prefecture of Kanto District and Niigata Prefecture of Hokuriku District in eastern Honshu, and is parapatric with *O. japonicus* sensu stricto and *O. nipponoborealis* (SW-Honshu and N-Tohoku groups in previous studies, respectively) without distinct geographic barriers, and their distributional ranges slightly overlap in some localities near species boundaries. In spite of such distributional patterns, the S-Tohoku group was genetically

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#### APPENDIX 1. Referred and compared specimens.

- Onychodactylus intermedius* sp. nov.—**Adults:** A total of 14 specimens: one male (KUHE 39695) collected from the type locality on 10 May 2007 by K. Nishikawa and N. Yoshikawa; five males (KUHE 47436–47437, 47458–47459, 47924) from the type locality on 4 May 2013 by N. Yoshikawa; one male (KUHE 48303 on 8 November 2013) and one female (KUHE 48306 on 21 December 2013) all collected by S. Ihara, N. Yoshikawa, and F. Endo, from environs of Mt. Adatara, Otama-mura, Fukushima Prefecture; three males (KUHE 37691 collected on 30 May 2006 by N. Yoshikawa, KUHE 43310–43311 on 16 June 2009 by Y. Misawa and N. Yoshikawa) and three females (KUHE 38310 collected on 31 October 2006 by Y. Misawa, KUHE 42353 on 2 November 2008 by I. Niibe, KUHE 43380 on 30 May 2009 by I. Niibe), all from environs of Nagai Dam, Nagai-shi, Yamagata Prefecture. **Larvae:** Sakata-shi (formerly Hirata-machi), Yamagata Pref.: KUHE 37592–37600; Nagai-shi, Yamagata Pref.: KUHE 43316–43322; Shichikashuku-machi, Miyagi Pref.: KUHE 36502–36511, 36514; Murakami-shi (formerly Sanboku-machi), Niigata Pref.: KUHE 44724–44727, 44740; Murakami-shi (formerly Asahi-mura): KUHE 36870–36875, 36879–36885; Otama-mura, Fukushima Pref.: KUHE 48130–48138, 48181–48186; Koriyama-shi, Fukushima Pref. (type locality): KUHE 47316–47346, 47916–47923, 48168–48173, 48188–48199.
- O. fuscus* sp. nov.—**Larvae:** Sanjo-shi, Niigata Pref.: KUHE 47371–47374, 47376.
- O. japonicus*—**Adults:** Shirakawa-shi (formerly Taishin-mura), Fukushima Pref.: KUHE 21657–21684; Sanjo-shi, Niigata Pref.: KUHE 47451 (juvenile); Nikko-shi (formerly Kuriyama-mura), Tochigi Pref.: KUHE 37798–37801, 37811–37831, 42009–42026, 42099–42109, 42996; Daigo-machi, Ibaraki Pref.: 37180–37182, 42351, 42986–42992, 43000, 43918–43919, 43921–43922, 48162; Yokoze-machi, Saitama Pref.: KUHE43851; Kawakami-mura, Nagano Pref.: KUHE 42267, 47596; Hakone-machi, Kanagawa Pref. (topotype): KUHE 46611–46615; Hadano-shi, Kanagawa Pref.: KUHE 46618–46619; Yamakita-machi, Kanagawa Pref.: KUHE 46616–46617; Gotemba-shi, Shizuoka Pref.: KUHE 45989; Kanagawa Pref. environs of Hakone: NSMT-H 00384–00391; Shiso-shi (formerly Ichinomiya-cho), Hyogo Pref.: KUHE 46138–46142; Shobara-shi (formerly Takano-cho), Hiroshima Pref.: KUHE 34701–34703, 42785, 42787; Aki-ota-cho (formerly Togochi-cho), Hiroshima Pref.: KUHE 17829–17831; Hatsukaichi-shi (formerly Yoshiwa-mura), Hiroshima Pref.: KUHE 37784, 39842–39843, 40195, 40197, 41726–41727, 41729, 43369–43370, 43374–43375; Iwakuni-shi (formerly Nishiki-cho), Yamaguchi Pref.: KUHE 42852, 42854. **Larvae:** Hakone-machi, Kanagawa Pref. (topotype): KUHE 46600–46610; Gotemba-shi, Shizuoka Pref.: KUHE 45990–45991; Izu-shi, Shizuoka Pref.: KUHE 36746–36749, 36763–36771, 39985–39995; Sanjo-shi, Niigata Pref.: KUHE 47375, 47377–47379; Tadami-machi, Fukushima Pref.: KUHE 48174–48176.
- O. kinneburii*—**Adults (including type series):** Ino-cho, Kochi Pref. (type locality): KUHE 43050, 43060–43066, 43137, 43190–43200, OMM-Am1–29; Mt. Kuishi, Kochi-shi (formerly Tosayama-mura), Kochi Pref.: KUHE 18034; Mt. Tsurugi, Miyoshi-shi (formerly Higashi-iyayama-mura), Tokushima Pref.: KUHE 8329–8330, 369333–6934, T1957, T3062, T3295, T3448, NSMT-H 01170; Mt. Kurokasa, Miyoshi-shi (formerly Higashi-iyayama-mura), Tokushima Pref.: KUHE 46358, 46404; Mt. Ishizuchi, Kumakogen-cho (formerly Omogo-mura), Ehime Pref.: T1598, KUHE 43528; Mt. Kanmuri, Hatsukaichi-shi (formerly Yoshiwa-mura), Hiroshima Pref.: KUHE 37785–37786, 40196, 41725; Mt. Jakuchi, Iwakuni-shi (formerly Nishiki-cho), Yamaguchi Pref.: KUHE 42851, 42853. **Larvae:** Mt. Kurokasa, Miyoshi-shi (formerly Higashi-iyayama-mura), Tokushima Pref.: KUHE 46179–46198, 46318–46340; Mt. Ishizuchi, Saijo-shi, Ehime

Pref.: KUHE 36859–36866, T3302–T3303, KUHE 39904–39927; Mt. Ishizuchi, Kumakogen-cho (formerly Omogomura), Ehime Pref.: KUHE 41736–41741; Ino-cho, Kochi Pref. (type locality): KUHE 43089–43092.

*O. nipponoborealis*—**Adults (including type series)**: Sai-mura, Aomori Pref.: KUHE 46385–46386, 46388–46392; Hirakawa-shi, Aomori Pref. (Type series): NSMT-H 05710–05714; Kita-akita-shi, Akita Pref.: KUHE 37707; Noda-mura, Iwate Pref.: KUHE 37022–37025; Kuji-shi (formerly Yamagata-mura), Iwate Pref.: NSMT-H 01172–01174; Iwaizumi-cho, Iwate Pref.: NSMT-H 01159–01160, 02063; Mt. Hayachine, Iwate Pref.: NSMT-H 01165–01166; Oshu-shi, Iwate Pref.: KUHE 45644–45646; Ichinoseki-shi, Iwate Pref.: KUHE 35276; Izumi-ku, Sendai-shi, Miyagi Pref.: KUHE 41348, 45868–45878, 45881, 45883–45885, 45887. **Larvae**: Izumi-ku, Sendai-shi, Miyagi Pref.: KUHE 45666–45698.

*O. tsukubaensis*—**Adults (Type series)**: Mt. Tsukuba, Tsukuba-shi, Ibaraki Pref.: KUHE 37418, 42733–42738, 44779, 44930–44933; Mt. Tsukuba, Sakuragawa-shi Ibaraki Pref.: KUHE 41388–41389, 42462; Mt. Kaba, Sakuragawa-shi, Ibaraki Pref.: KUHE 39783. **Larvae**: Mt. Tsukuba, Tsukuba-shi, Ibaraki Pref.: KUHE 41378–41387, 42741, 42801–42804; Mt. Tsukuba, Sakuragawa-shi, Ibaraki Pref.: KUHE 36556–36566, 36573–36578; Mt. Kaba, Sakuragawa-shi, Ibaraki Pref.: KUHE 39769–39778, 39782, 41375–41376; Mt. Kaba, Ishioka-shi, Ibaraki Pref.: KUHE 42743–42745, 42792–42797, 42799–42800, 43910–43915.

*O. koreanus*—**Adults**: South Korea (exact locality unknown): KUHE 11196–11205.

*O. fischeri*—**Adults**: Olginskij Country, Primorskiy Kray, Russia: NSMT-H 04471–04473; Sestra, Primorskiy Kray, Russia: NSMT-H 04487–04489; Mt. Obrochnoye, Primorskiy Kray, Russia: NSMT-H 04504; Mt. Konstantinopol, Primorskiy Kray, Russia: NSMT-H 04505–04507; Mt. Krinichnaja, Primorskiy Kray, Russia: NSMT-H 04525; Primorskiy Kray, Russia, exact locality unknown: KUHE 46913.

## APPENDIX 2. Measurements taken in this study.

1) snout-vent length (SVL), from snout to anterior angle of cloaca; 2) head length (HL), from tip of snout to gular fold; 3) head width (HW), measured at jaw articulation; 4) tail length (TAL), from anterior angle of cloaca to tip of tail; 5) axilla-groin distance (AGD), distance between axilla and groin (only for right side); 6) forelimb length (FLL), distance from axilla to tip of longest finger (measured separately on right and left sides); 7) hindlimb length (HLL), distance from groin to tip of longest toe (measured separately on right and left sides); 8) upper eyelid length (UEL), maximum length of upper eyelid (measured separately on right and left sides); 9) interorbital distance (IOD), minimum distance between upper eyelids; 10) eye-nostril distance (END), minimum distance between eye and nostril (measured separately on right and left sides); 11) intercanthal distance (ICD), minimum distance between anterior corners of eyes; 12) internarial distance (IND), minimum distance between external nares; 13) snout length (SL), tip of snout to anterior corner of eye (measured separately on right and left sides); 14) chest width (CW), minimum distance between right and left axillae; 15) basal tail height (BTAH), height of tail at anterior angle of cloaca; 16) basal tail width (BTAW), width of tail at anterior angle of cloaca; 17) medial tail height (MTAH), height of tail at midpoint; 18) medial tail width (MTAW), width of tail at midpoint.

## APPENDIX 3. Locality information of samples used for phylogenetic analysis shown in Fig. 2.

*Onychodactylus intermedius* **sp. nov.**: (1) Sakata-shi, Yamagata Pref. (n = 1). (2) Sakata-shi, Yamagata Pref. (n = 2). (3) Nishikawa-machi, Yamagata Pref. (n = 1). (4) Nagai-shi, Yamagata Pref. (n = 1). (5) Yonezawa-shi, Yamagata Pref. (n = 1). (6) Murakami-shi, Niigata Pref. (n = 3). (7) Murakami-shi (formerly Asahi-mura), Niigata Pref. (n = 3). (8) Shichikashuku-machi, Miyagi Pref. (n = 2). (9) Kitashiobara-mura, Fukushima Pref. (n = 2). (10) Otama-mura, Fukushima Pref. (n = 12). (11) Koriyama-shi, Fukushima Pref. (n = 1). (12) Koriyama-shi, Fukushima Pref. (typelocaliy, including holotype: n = 8). (13) Koriyama-shi, Fukushima Pref. (n = 11). (14) Aizuwakamatsu-shi, Fukushima Pref. (n = 11). (15) Nihonmatsu-shi, Fukushima Pref. (n = 1). (16) Tamura-shi, Fukushima Pref. (n = 2). (17) Kawachi-mura, Fukushima Pref. (n = 1). (18) Iwaki-shi, Fukushima Pref. (n = 1). (19) Samegawa-mura, Fukushima Pref. (n = 1). (20) Kitaibaraki-shi, Ibaraki Pref. (n = 3). (21) Takahagi-shi, Ibaraki Pref. (n = 1). (22) Hitachiota-shi, Ibaraki Pref. (n = 1).

*O. fuscus* **sp. nov.**: (23) Tadami-machi, Fukushima Pref. (type locality, including holotype: n = 7). (24) Sanjo-shi, Niigata Pref. (n = 9).

*O. nipponoborealis*: (25) Sai-mura, Aomori Pref. (n = 1). (26) Hirakawa-shi, Aomori Pref. (n = 1). (27) Oshu-shi, Iwate Pref. (n = 1). (28) Yurihonjo-shi, Akita Pref. (n = 1). (29) Kesenuma-shi, Miyagi Pref. (n = 1). (30) Taiwa-cho, Miyagi Pref. (n = 1). (31) Sendai-shi, Miyagi Pref. (n = 1). (32) Yamagata-shi, Yamagata Pref. (n = 1). (33) Kaminoyama-shi, Yamagata Pref. (n = 1). (34) Sakata-shi, Yamagata Pref. (n = 3).

*O. tsukubaensis*: (35) Sakuragawa-shi, Ibaraki Pref. (type locality, holotype: n = 1).

*O. japonicus*: (36) Aga-machi, Niigata Pref. (n = 1). (37) Yahiko-mura, Niigata Pref. (n = 1). (38) Sanjo-shi, Niigata Pref. (n = 5). (39) Kitakata-shi, Fukushima Pref. (n = 5). (40) Aizuwakamatsu-shi, Fukushima Pref. (n = 2). (41) Kaneyama-machi, Fukushima Pref. (n = 5). (42) Tadami-machi, Fukushima Pref. (n = 3). (43) Hinoemata-mura, Fukushima Pref. (n = 1). (44) Shirakawa-shi, Fukushima Pref. (n = 1). (45) Daigo-machi, Ibaraki Pref. (n = 2). (46) Nikko-shi, Tochigi Pref. (n = 2). (47) Naganohara-machi, Gunma Pref. (n = 1). (48) Okutama-machi, Tokyo (n = 1). (49) Hakone-machi, Kanagawa Pref. (type

locality: n = 1). (50) Izu-shi, Shizuoka Pref. (n = 1). (51) Shirakawa-mura, Gifu Pref. (n = 1). (52) Hatsukaichi-shi, Hiroshima Pref. (n = 1).  
*O. sp.* Kinki group: (53) Kyoto-shi, Kyoto Pref. (n = 1).  
*O. kinneburi*: (54) Ino-cho, Kochi Pref. (type locality, holotype: n = 1).  
*O. koreanus*: (55) Weonju-shi, Kangwon-do, South Korea (n = 1).  
*O. fischeri*: (56) Shkotovo, Primorskiy Kray, Russia (n = 1).