野外調査と室内実験による外来性ワラジムシ類オカダンゴムシの歩行分散力の推定

誌名	Edaphologia
ISSN	03891445
著者名	古川,智之 水島,萌美 堀之薗,訓貴 唐沢,重考
発行元	日本土壌動物研究会
巻/号	101号
掲載ページ	p. 27-32
発行年月	2017年10月

Short Communication

Estimation of the walking ability of an exotic terrestrial isopod *Armadillidium vulgare* Latreille by field and laboratory measurements

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Received: 2 February 2017; Accepted 30 April 2017

Abstract Migration distance is an important determinant of the distribution area of animals and is an important factor influencing community structure. However, a few studies have reported the walking distance of terrestrial isopods. The walking distance of an exotic terrestrial isopod *Armadillidium vulgare* (Latreille, 1804) was analyzed by field and laboratory measurements. A mark-and-recapture field survey indicated that *A. vulgare* could walk 24 m per day and up to 51 m over 8 days. Moreover, this species walked about 50 m in one hour under experimental conditions (0.8 lux, 22°C). The walking ability of *A. vulgare* is similar to the migration distances of flying beetles and a grasshopper.

Key words: Armadillidiidae, Crustacea, Mark-and-recapture method, Oniscidea

Introduction

Terrestrial isopods are often the dominant macro-invertebrates in soil communities in Japan (e.g., Ikehara *et al.*, 1977; Karasawa, 2009). They play important roles as organic decomposers (Zimmer, 2002) and are food items for amphibians (Ihara, 1998). In Japan, at least seven exotic species have been reported (The Japanese Society of Soil Zoology, 2007) so it is important to evaluate their effect on native soil ecosystems. *Armadillidium vulgare* (Latreille, 1804) is a worldwide exotic species (Schmalfuss, 2003) and is widely distributed in Japan, from Hokkaido to Miyakojima Island (Nunomura, 1990; Karasawa, 2013). Moreover, this species is widely distributed on a regional scale (within cities and towns) and has been found in more than 100 artificial environments (road-side, urban parks, parking areas) in Munakata City, Fukuoka, Japan (unpublished data). Clearly, this species can be transported by human activities over large distances between countries but high walking ability is required for these isopods to become widely distributed at the regional scale. Knowledge of migration ability is essential to estimate the spread of exotic species (Koike and Iwasaki, 2011; Osawa *et al.*, 2013). However, there are a few studies of the walking ability of exotic terrestrial isopods (Paris, 1965), although other aspects of their locomotion have been well researched, e.g., crowding (Boer, 1961; Ganter, 1984), alternative turning (Moriyama *et al.*, 2016), diurnal epigeic activity (Tuf and Jeřábková, 2008), memory (Stottlemeyer and Kaut, 2011), and searching behavior of desert species (Hoffmann, 1984).

The aim of this study was to reveal the potential walking ability of *A. vulgare* under experimental conditions and their actual walking ability under natural conditions in Japan. The mark-and-recapture method was used to determine walking distance in the field. Potential walking distance was measured by video recording under experimental conditions.

Materials and methods

Field survey

Measurements of walking distance were carried out using the mark-and-recapture method (Southwood and Henderson, 2000) in Fukuoka University of Education, where *A. vulgare* is a dominant species. Twenty-eight sites were established around

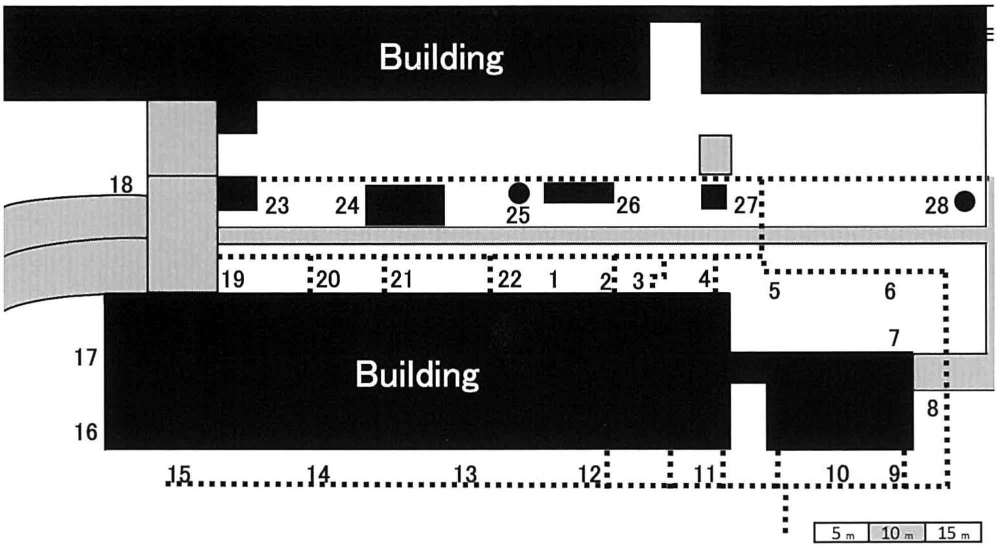

Fig 1. Sampling sites. Numbers represent the sites at which marked samples were recaptured. Site 1 was the release point at the start of each survey. Black: buildings and concrete structures; Gray: asphalt and concrete roads; Dashed line: concrete drainages.

the buildings of the Departments of Science and Homemaking (Fig. 1); Site 1 was the release point. The sites were defined by driving stakes. Distances between sites (stakes) were measured using a tape measure; the farthest site from Site 1 was Site 14, at a distance of 77 m. As the walking ability of terrestrial isopods might be affected by season (Hornung, 2011), the field surveys were carried out in early summer (16–27 June 2013) and autumn (2 September to 11 November 2010). A few days before each survey, 594 specimens of *A. vulgare* (361 males and 233 females) in the summer survey, and 634 specimens (228 males and 306 females) in the autumn survey, were collected from the study sites. Until the start of the field surveys, the isopods were reared in a plastic box (27 cm × 20 cm), the bottom of which was covered with sand (ca. 2 cm deep). Carrot and leaf litter were given for food. Red or yellow marks were painted on the back of each specimen using permanent markers (PX-21, Mitsubishi Pencil Co., Ltd.), and all specimens were released at Site 1 on 2 September 2010 (autumn) and 16 June 2013 (summer) (Fig. 1). In the autumn survey, specimens were recaptured 1, 2, 3, 4, 8, 15 and 80 days after release. In the summer survey, which coincides with the rainy season, specimens were recaptured 1, 2, 6, 7, 9 days after of the release, avoiding wet days. Recapture was carried out by a single person who searched for marked specimens for 7 minutes 30 seconds within 3 m from each stake.

Laboratory measurements

To evaluate the walking potential of *A. vulgare*, walking distance was also measured in an arena under experimental conditions. The arena consisted of sponge-rubber bottom (13.4 cm diameter) and plastic-sheet wall (3 cm high). The arena was situated in the dark (0.8 lux) at 22.0°C; humidity was not controlled. *Armadillidium vulgare* were collected from Fukuoka University of Education and placed into the arena without delay. After putting specimens into the experimental arena, the arena was monitored and recorded for 2 hours with a digital video camera (HDR-SR11, Sony Corporation) situated 50 cm above the arena. The first hour was excluded from the analysis to allow the isopods to acclimate to the experimental conditions. Data from the second hour were transferred to a personal computer and movements of *A. vulgare* were traced using the software MoveTr2D (Library Co., Ltd.). The software recorded the positions (X and Y axes) of the specimens every 0.03 s, and their walking distances in one hour were calculated. The laboratory measurements were carried out in winter (December 2013 to February 2014) and summer (August and September 2010, July and August 2014). Forty males (31 specimens in summer, 9 specimens in winter) and 20 females (all specimens in summer) were used for the experiment. The body weights of the experimental specimens ranged from 60 to 120 mg; there was no difference in mean weight between males and females.

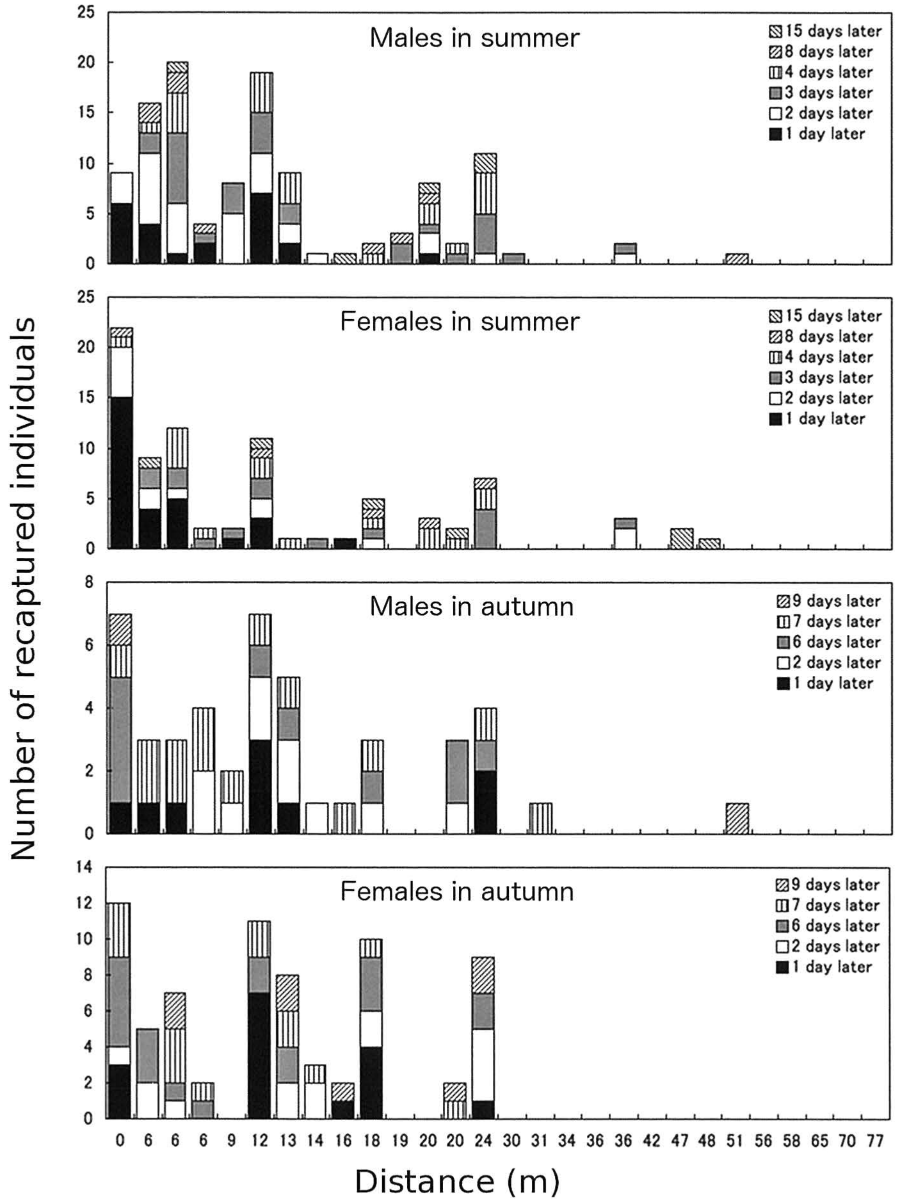

Fig 2. Cumulative numbers recaptured at sites at different distances from the release point (Site 1).

Results and Discussion

Knowledge of migration ability is essential to estimate the potential distribution area of exotic species (Koike and Iwasaki, 2011; Osawa *et al.*, 2013). Migration ability is also an important factor determining community structure (Hubbel, 2001). Soil animals usually are considered to have low migration ability; however, apart from studies of carabid beetles (see references in Kubota, 1996), few comparative data are available for animals considered to have high migration ability (Tokue *et al.*, 2011). There have been several studies on the walking behavior of terrestrial isopods (Hornung, 2011; see Introduction), but only a few studies have revealed the walking distance in this group. For example, the use of radioactive tags showed that *A. vulgare* walked 13 m in 12 hours in summer, and that the greatest distance travelled was 25 m during 20 days (Paris, 1965). Moreover, a desert isopod species, *Hemilepistus reaumuri* (Milne-Edwards, 1840) walked 247–548 m over 4–5 days (Warburg *et al.*, 1984).

A total of 317 specimens were recaptured during the experimental period (Fig. 2). Similar numbers of males

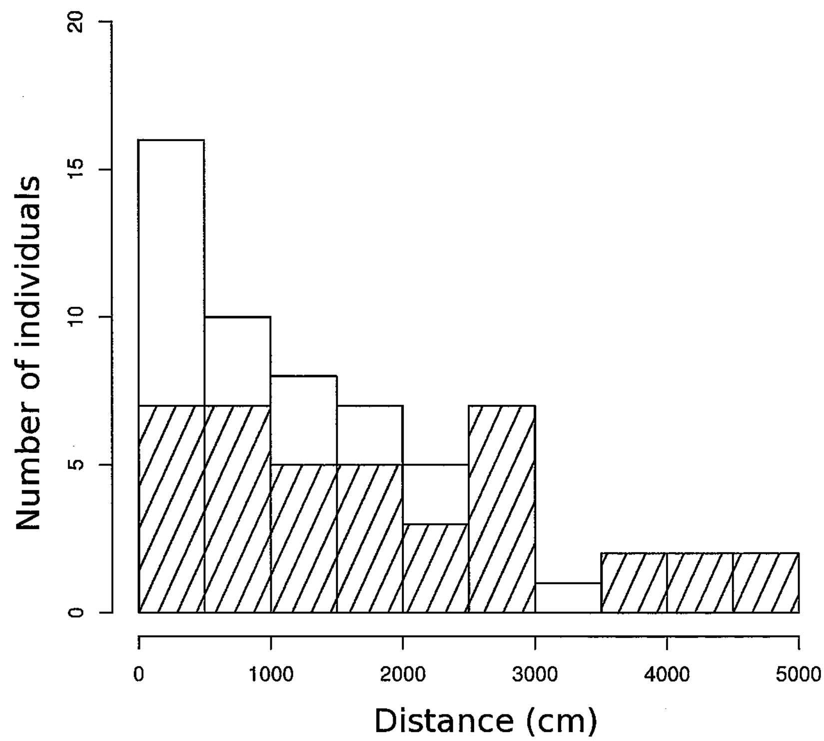

Fig 3. Walking distances of *Armadillidium vulgare* under experimental conditions. Obliquely shaped and clear bars represent males and females, respectively.

(162) and females (155) were recaptured but more isopods were recaptured in summer (201) than in autumn (116). The difference reflects both seasonal activity and a difference in the number of sampling occasions between summer (7) and autumn (5). Only 50 specimens were recaptured at the release point. However, 1 day after release, three specimens were found at a site 24 m from the release site in autumn. During the whole study period, the greatest distance of recapture was at Site 16, 51 m from the release site. At this site, one male was found after 8 days in summer and after 9 days in autumn. The furthest distance of recapture of a female was at Site 10, 48 m from the release point. The field survey showed that *A. vulgare* could walk 24 m in 1 day and at least 50 m in the field. These walking distances are greater than in a previous report (25 m in 20 days; Paris, 1965) and similar to those recorded for some ground beetles (*Carabus* spp.; Kubota, 1996). In addition, the present study investigated the potential walking ability of *A. vulgare* under experimental conditions and observed walking distances ranging from 12 cm to 49 m in one hour (Fig. 3). The field survey obviously underestimated their walking ability, because there were several problems in the experiments: *A. vulgare* marked with nail polish and queen-bee marker show less activity than unmarked individuals (Drahokoupilová and Tuf, 2012); painted markers on terrestrial isopods may be lost after quite short periods, depending on molting cycles (65%–75% and less than 25% of the marked specimens were recorded after one week and one month, respectively; Tuf *et al.*, 2013); the present field study could not measure the walking distance of specimens outside the studied region. It is doubtful that *A. vulgare* walked more than 50 m from the release point during the study period. Drahokoupilová and Tuf (2012) monitored behaviour of *A. vulgare* for 24 hours. That study showed that this species was usually active (feeding and/or exploring) for around 3 hours at night. If they maintained their maximum walking speed (49 m per hour) for this period during the night, they could move about 150 m per day, although precise estimation of the walking distance would require a carefully prepared experiment.

Wingless soil-arthropods have usually lower migration abilities than flying insects. Maekawa (2005) measured migration distances of some flying beetles (*Trypoxylus* *dichotomus* (Linnaeus, 1771), *Dorcus striatipennis* (Motschulsky, 1861), *D. rectus* (Motschulsky, 1857), *Prosopocoilus inclinatus* (Motschulsky, 1857)) using traps and the mark-and-recapture method. This author sampled twice per week and found that most of the marked individuals were recaptured within 150 m of the release points. Moreover, a grasshopper (*Mecopoda nipponensis* (Haan, 1842)) was recaptured only 100 m from the release point after 13 days (Imai *et al*., 2005). The present observations imply that the walking ability of *A. vulgare* matches the migration ability of some winged insects, which could be one of the factors that has enabled this species to become widely distributed at the regional scale.

Acknowledgements

We thank members of Laboratory of Animal Ecology in Fukuoka University of Education for helping with the field survey and referees for valuable comments. This work was supported by JSPS KAKENHI Grant Number 26830145.

摘 要

古川智之[1]・水島萌美[1]・堀之薗訓貴[1]・唐沢重考[2]（[1]福岡教育大学 〒811-4192 福岡県宗像市赤間文教町 1-1・[2]鳥取大学農学部 〒680-8551 鳥取県鳥取市湖山町南 4-101）：野外調査と室内実験による外来性ワラジムシ類オカダンゴムシの歩行分散力の推定．

分散力は生息域の推定や群集構造を解明する上で極めて重要である．しかし，ワラジムシ類に関する知見は極めて乏しい．そこで，本研究では，野外調査と室内実験により外来性ワラジムシ類であるオカダンゴムシの歩行分散力を明らかにした．野外で行った標識再捕法によりオカダンゴムシは 1 日で 24 m，8 日で 51 m 移動することが明らかとなった．また，0.8 lux，22°C に設定した実験条件における歩行分散力の計測では 1 時間で 50 m 歩行する個体が確認された．これらの結果から本種の歩行分散力は飛翔能力をもつ大型甲虫やクツワムシに匹敵する可能性が示唆された．

キーワード：オカダンゴムシ科，甲殻類，標識再捕法，ワラジムシ亜目

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