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Short Communication

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Boxwood Borer *Heterobostrychus brunneus* (Coleoptera: Bostrichidae) Infesting Dried Cassava: A Current Record from Southern Ethiopia

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Abstract

Insect specimens of adult beetles and larvae of 7–9 and 9–10 mm length, respectively were collected from infested dry cassava at two locations from multiple stores in southern Ethiopia. The specimens were identified as *Heterobostrychus brunneus* (Murray, 1867) commonly known as boxwood borer and auger beetle. The study presents a current record of *H. brunneus* in Ethiopia, particularly in the context of infesting food products. Additionally, a wide geographical distribution of the pest was reviewed and presented in this article. Current evidence suggests that *H. brunneus* is a serious pest of forest wood, structural timbers, and dried food products and that it carries a risk to be introduced into various other parts of the world via global trade.

Key words: Cassava, COI, Ethiopia, *Heterobostrychus brunneus*

The genus *Heterobostrychus* Lesne, 1899 belongs to the Bostrichidae family and comprises species that are commonly considered as forest wood pests that can also infest foodstuff and household structural timbers. Most of the bostrichids are known to be polyphagous in nature; both adult and larvae feed on a variety of woods and obtain their nutrition from starch and sugars present in their hosts. Moreover, some species can also feed on food products (Hill 2002, Liu et al. 2008). Species belonging to *Heterobostrychus* are notorious pests of significant economic importance in tropical and subtropical regions and are categorized as powder-post beetle because of their peculiar nature of reducing the wood to powdery dust (Findlay 1985, Liu et al. 2008, Azmi et al. 2011). Six known species of the genus are *H. aequalis* (Waterhouse, 1884), *H. ambigenus* (Lesne, 1920), *H. brunneus* (Murray, 1867), *H. hamatipennis* (Lesne, 1895), *H. pileatus* (Lesne, 1899), and *H. unicornis* (Waterhouse, 1879) (Beiriger 2010, ITIS 2016). Some species of the genus (*H. aequalis, H. brunneus and H. hamatipennis*) have regularly been introduced in various parts of the world (Borowski and Wegrzynowicz 2007) due to increased global trade in timber and wood products. According to Azmi et al. (2011), one of the species (*H. aequalis*) was introduced most likely via trade to various countries, including Belgium, Canada, France, Germany, Israel, Italy, Japan, New Zealand, and the United States.

H. brunneus is commonly called boxwood borer due to its presence in hardwood packings. This habit makes it a quarantine pest in many countries where the species is non-endemic or not yet established (Wylie et al. 2008). Adults and larvae of *H. brunneus* can affect timber in green condition and after seasoning (Findlay 1985). The beetle is about 6–13 mm long and dark reddish brown to black in color. Full grown larvae are pale yellow and about 7–10 mm long (Fisher 1950, Robinson 2005). Booth et al. (1990) describe *H. brunneus* as being similar to *H. aequalis* but having recumbent hair and an absence of tubercles on the top margins of the elytral declivity.

Cassava (*Manihot esculenta* Crantz) is an important root crop and is cultivated in various parts of Africa, Asia, and South America. Globally, cassava is the sixth largest crop after wheat, rice, maize, potato, and barley (Lebot 2009). Estimates suggest it is a staple food for more than 800 million people, mostly living in the least industrialized tropical and sub-tropical regions of the world (Howeler et al. 2013). However, the subsistence status of this crop species is rapidly changing to a cash crop with its enhanced usage in multiple industrial applications such as the production of paper, textile, plywood, glue, biofuel, animal feed and beverage. Cassava in Ethiopia is relatively new, it was introduced in 1960, but its importance dramatically increased in the country after the famine of 1984 (Kebede et al. 2012). Presently, it is an important crop in the south

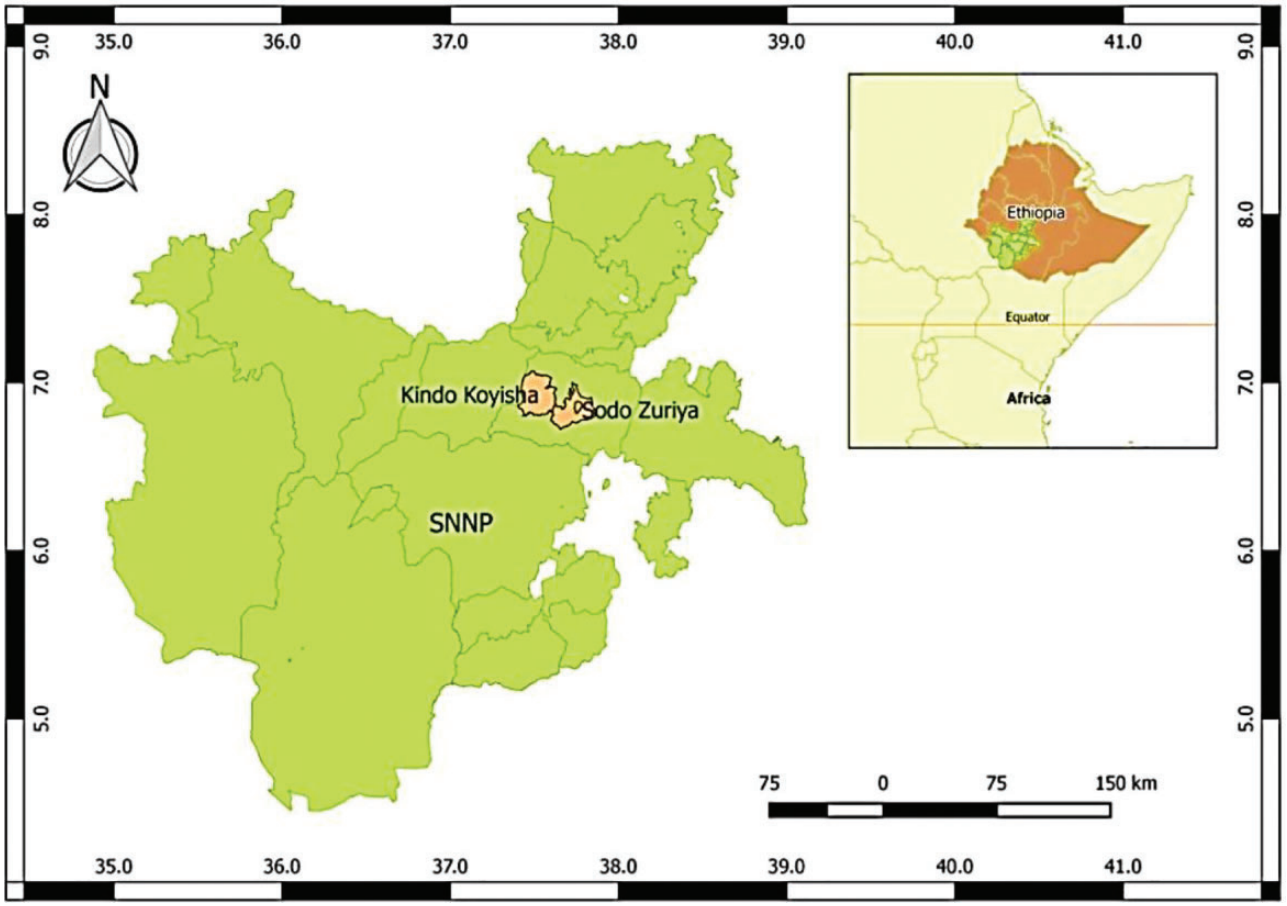

Fig. 1. Sites from where specimens of the adult and larvae (*H. brunneus*) were collected [SNNP (Southern Nations, Nationalities, and Peoples') Region]. Bale - N6° 55.175′ E37° 32.075′, Elevation: 1245m asl; Sodo - N6° 51.481′ E37° 46.141′. Elevation: 2017m asl.

and south-western parts of Ethiopia where the local population tends to rely more on root crops.

During storage, dried cassava is highly susceptible to a variety of storage insects and pests. The damage is intensified by tropical conditions resulting in significant weight loss in a short time (Hodges et al. 1985). Stumpf (1998) reported *H. brunneus* (Ghana) as a destructive pest of dried cassava. The species not only damages the dried products, but it has also been reported as a common stem borer for standing cassava plantations (Bellotti and van Schoonhoven 1978). Hence, the presence of *H. brunneus* poses a dual threat to cassava during production and storage and requires immediate attention for control and prevention. The purpose of this study is to provide details on the presence of *H. brunneus* infestation in the dried cassava chips and chunks during storage in southern Ethiopia. Key morphological features and DNA barcode of the species are reported. Additionally, a global distribution data for the species based on current information was generated.

Material and Methods

Location and Survey

A field survey to assess the post-harvest losses and related causes in the cassava value chain was conducted in Wolayita Zone of Southern Region (SNNPR) Ethiopia in October–December 2015. In the course of this study, 60 traders were surveyed by administering semi-structured questionnaires and conducting store inspection using pictographic illustrations of the main storage pests in three districts. Along with other more common insect species, unidentified black, brownish beetles (adults of 8–9 mm length) were presented and reported by traders infesting dried cassava chips at their storage systems. Sodo and Bale town in Sodo Zuriya and Kindo Koyisha districts, respectively were the two locations in the southern highland of Ethiopia from where the specimens were collected. The climate of Sodo is classified as warm and temperate (Köppen-Geiger: *Cfb*) with a mean annual temperature of 19.3 °C and 1,484 mm of annual precipitation (Gonfa 1996, Calimate Data Org 2016). Bale has a tropical climate (Köppen-Geiger: *Aw*) with a mean annual temperature and an annual precipitation of 22.7 °C and 1,200 mm, respectively (Gonfa 1996, Calimate Data Org 2016). The exact coordinates and elevations of the locations are presented in Figure 1.

The specimens of the unidentified adult beetles along with larvae were collected from the storage houses and kept in 70% ethanol until identification. The species was identified using several keys for adults (Fisher 1950, Walker 2005, Beiriger 2010) and larvae (Lesne 1924, Robinson 2005, Schabel 2006). The online source the Integrated Taxonomic Information System (ITIS 2016) and the Department of Entomology, Iowa State University the BugGuide (2016) were used for nomenclature classification.

Photographs of the specimens (Figs. 3–5) were taken with a stereomicroscope Leica-EZ4HD (Leica Microsystems, Wetzlar, Germany). DNA barcoding of the adult beetle was conducted, which was based on a 658-bp long region of the mitochondrial gene for cytochrome c oxidase I (COI) amplified using primers COL6 (5′- TYTCHACA

Table 1. Distribution of *H. brunneus* (Murray, 1867) based on current information.

Region	Status	Host	References
Africa			
Burundi	Present	NI*	Hagstrum and Subramanyam (2009)
Cameroon	Present	NI	Vrydagh (1960), Alene et al. (2005), EPPO (2016a)
Cape Verde	Present	Timber	Fisher (1950), EPPO (2016b)
Congo	Present	Logs	Fisher (1950), Borowski and Wegrzynowicz (2007), GBIF (2016)
Egypt	Present	NI	Borowski (2007), Hagstrum and Subramanyam (2009)
Ethiopia (Abyssinia)	Present	NI	Vrydagh (1960)
Gambia	Present	NI	GBIF (2016)
Ghana	Present	Cassava, sapwood, lumber	Ashiru (1989), Stumpf (1998), Wagner et al. (2008)
Ivory coast	Present	Wood	Becker (1980)
Kenya	Present	NI	Wasonga et al. (2015)
Madagascar	Present	NI	Fisher (1950)
Mozambique	Present	NI	Vrydagh (1955b)
Nigeria	Present	Lumber, dead logs	Roberts (1967), Ashiru (1989), Borowski and Wegrzynowicz (2007)
Rawanda	Present	NI	Hagstrum and Subramanyam (2009)
Senegal	Present	NI	GBIF (2016)
Seychelles Islands	Present	Timber	Fisher (1950), EPPO (2016b)
South Africa	Present	Bamboo, timber	Lesne (1924), Pringle (1938), Fisher (1950), GBIF (2016)
Sudan	Present	NI	Hagstrum and Subramanyam (2009)
The Republic of Guinea	Present	Potato tubers	Fisher (1950)
Tanzania	Present	Forest wood	Madoffe et al. (2000), Schabel (2006), GBIF (2016)
Togo	Present	NI	Vrydagh (1955a)
Uganda	Present	Dried sweet potato,	Davies (1960), Mwanga and Wanyera (1988)
Zambia	Present	Sawn Timber, Logs	Selander and Piearce (1984), Lemmens (2012)
Zimbabwe	Present	NI	Walker (2005), GBIF (2016)
Europe			
Belgium	Intercepted	NI	Borowski (2007), Hagstrum and Subramanyam (2009)
United Kingdom	Intercepted	NI	Borowski (2007), Hagstrum and Subramanyam (2009), Fauna Europaea (2016)
France	Intercepted	NI	Borowski (2007), Hagstrum and Subramanyam (2009), Brustel and Aberlenc (2014)
Germany	Intercepted	Imported timber or bamboo	Cymorek 1970), Borowski (2007), Fauna Europaea (2016), GBIF (2016)
Italy	Intercepted	Wood and wood products	Gambetta and Orlandi (1982), Audisio et al. (1995), Ratti (2004), Borowski (2007), Fauna Europaea (2016), GBIF (2016)
Poland	Intercepted	NI	Hagstrum and Subramanyam (2009), Borowski (2007)
Portugal	Intercepted	NI	Baena and Zuzarte (2013)
Spain	Intercepted	NI	Bahillo de la Puebla (2007), Borowski (2007), EPPO (2016a), Fauna Europaea (2016)
Middle East			
Israel	Present	Timber and wood products	Bytinski-Salz (1966), Halperin and Damoiseau (1980), EPPO (2016b)
North America			
USA, New York	Intercepted	Wood boxes	Fisher (1950)
USA, California	Present	Wood, lumber, logs	Ivie (2002) Haack (2006), Hayes and Lundquist (2007), Beiriger (2010)
USA, Florida	Intercepted	Wood products	Woodruff and Fasulo (2006)
South America			
French Guiana	Present	NI	EPPO (2016b)
Asia			
China	Intercepted	Timber imported from Africa	Wei and Guangqin (1994), Zhi-Lin (2003)
Sri-Lanka	Present	Timber	De Silva and Amarasekara (1998)
Oceania			
New Zealand	Intercepted	NI	Archibald and Chalmers (1983)

Present—established and infested. **Intercepted**—identified as introduced in the country (Establishment is doubtful) NI*, No information.

AAYCATAAAGAYATYGG-3′) and COH6 (5′- TADACTTCDG GRTGDCCAAARAAYCA-3′) (Schubart 2009).

Distribution

A literature review was conducted to build a global distribution data where the pest has been present or intercepted before. The primary databases used were Google Scholar, Science Direct, CAB Direct, Web of Science, Zoological Record, and unsystematic exploration using Google search engine. Other than that books and documents were located at universities and national research center. The keywords used for search were *Heterobostrychus brunneus, Ethiopia, Cassava pests, and tropical wood pests*.

Results and Discussion

Distribution

Information on the geographical distribution of *H. brunneus* is currently limited. The European and Mediterranean Plant Protection

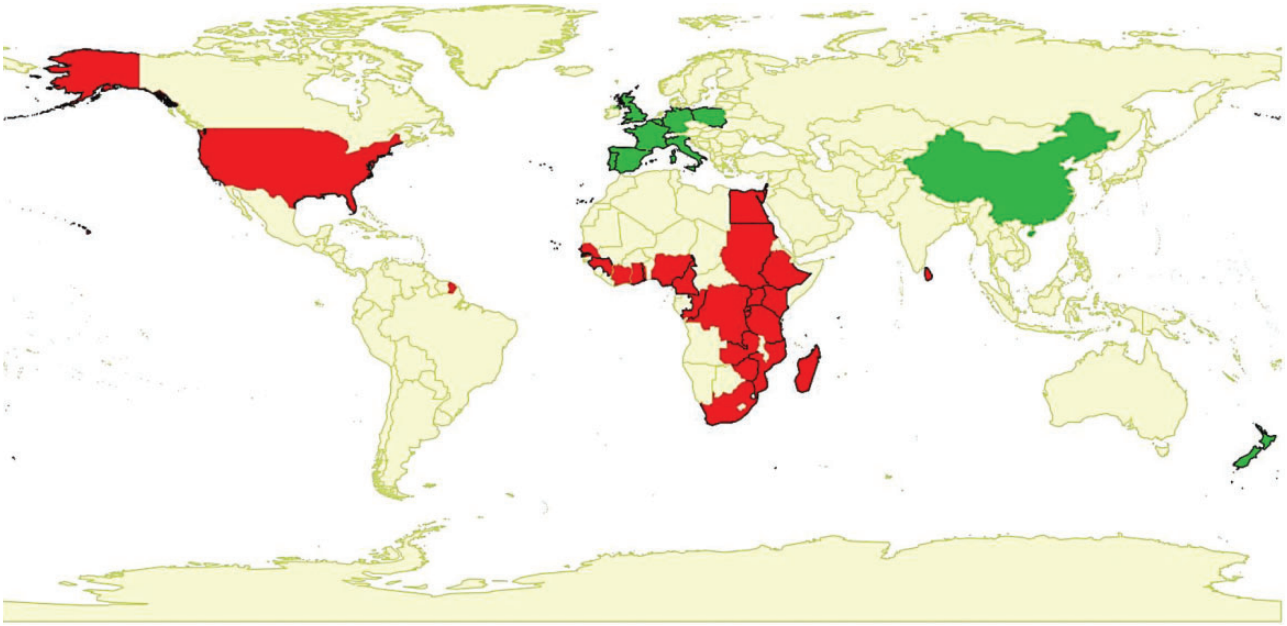

Fig. 2. *H. brunneus* global distribution map [Red, Present; Green, Intercepted]. (Source: Authors. Produced by: Quantum GIS Geographic Information System, Version 2.8.2 (Vancouver, British Columbia, Canada). Resolution: 1,000 dpi)

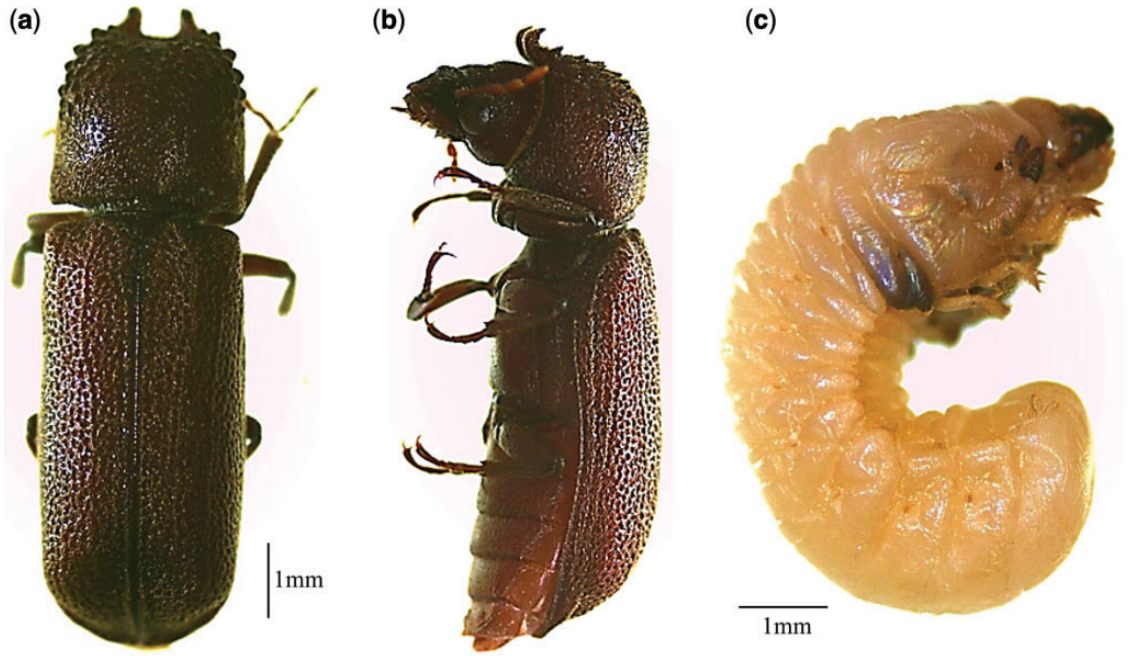

Fig. 3. *H. brunneus* adult (a) Dorsal view, (b) Lateral view and fourth instar larvae (c) Lateral view. (Photos by Aditya Parmar; Collected at Sodo).

Organization (EPPO 2016a,b) and Borowski and Wegrzynowicz (2007) list various countries, namely Cape Verde, French Guiana, Israel, Madagascar, Nigeria, Seychelles, and South Africa. Booth et al. (1990) and Walker (2005) mention Africa as a whole in distribution but do not give specific accounts per country. The geographical distribution of *H. brunneus* provided by ITIS (2016) provides information only at the level of the continent (Africa, Asia, Australia, Europe, and North America) but lacks specific locations. GBIF (2016) lists several countries in Africa and Europe. Fauna Europaea (2016) and Borowski (2007) state the possible presence (interceptions) of species in Germany, Italy, Spain and United Kingdom. Based on the published information and archives, a list of countries was prepared where *H. brunneus* has been reported previously (Table 1 and Fig. 2). Current literature on stored food product's insects and pests from Ethiopia is devoid of information regarding the presence and infestation of *H. brunneus* (Walker and Boxall 1974, Abate 1988, Tadesse et al. 2006, Hagstrum et al. 2013).

Some of the popular hosts of the insect pest which were listed by Fisher (1950) were bamboo (*Poaceae*, *Bambusoideae*) in southern

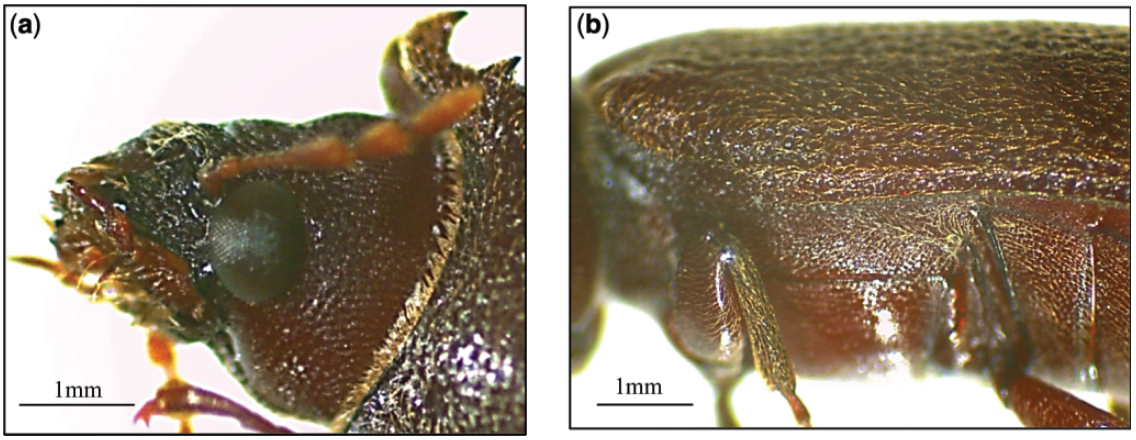

Fig. 4. *H. brunneus* adult: (a) Eye; (b) Thorax lateral view.

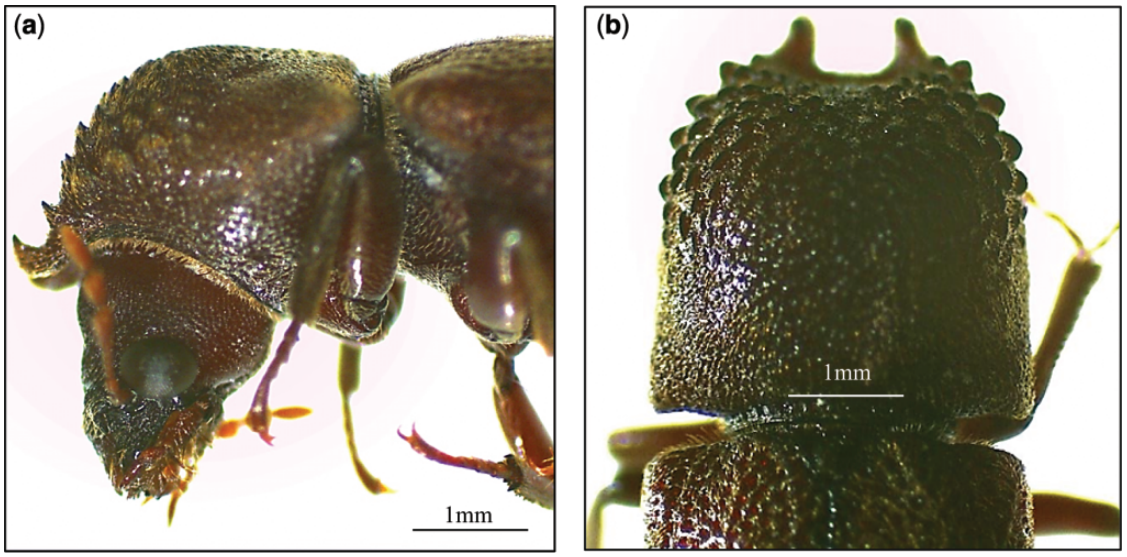

Fig. 5. *H. brunneus* adult: (a) Head lateral (or side) view; (b) Pronotum dorsal view.

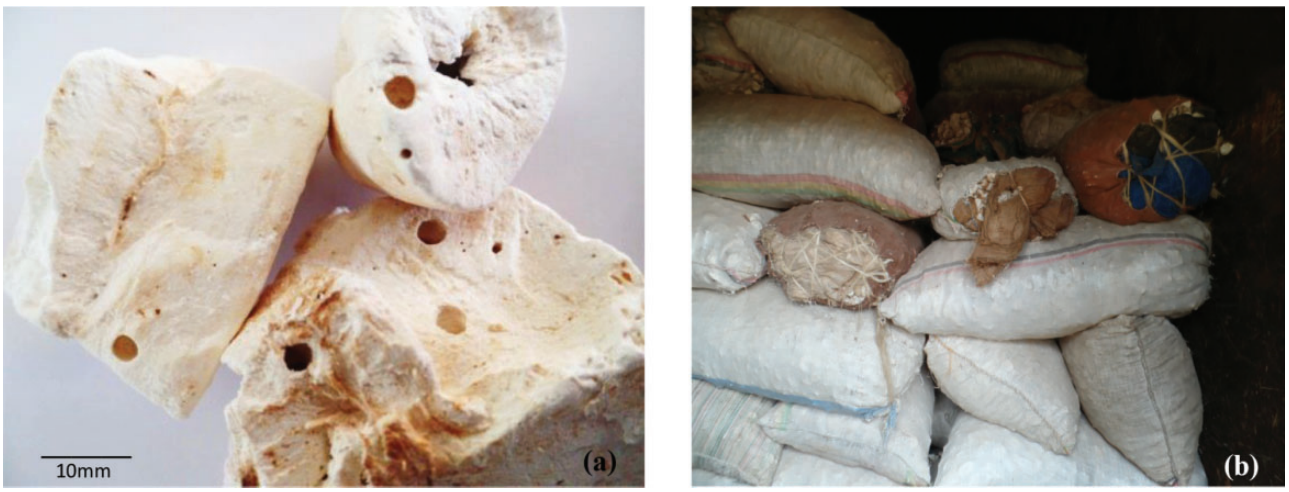

Fig. 6. Representative holes on cassava chips (a) infested by *H. brunneus* and cassava storage house (b).

Africa; potato from French Guinea and sapwood of various tree species such as African teak (*Baikiaea plurijuga*), Kiaat (*Pterocarpus angolensis*), and Eucalyptus (*Eucalyptus* spp.). *H. brunneus* has been reported to infest stored foodstuffs such as coffee (*Coffea* ssp.) beans, cassava (*M. esculenta*), sweet potato (*Ipomoea batatas*), pulses and oil seeds in tropical regions (Mwanga and Wanyera 1988, Stumpf 1998, Golob et al. 2002, Hill 2002).

Morphology and DNA Barcode

The collected beetle species in cassava storages houses of traders was identified as *Heterobosytrychus brunneus*. Figure 3 provides a pictorial illustration of adult and larvae of the species. Adult beetles have black to dark brownish color and a length of about 7–8 mm and 3–3.5 mm in width. The fourth- to fifth-instar larvae are of pale yellow to whitish color with black mandibles and 9–10 mm long fully elongated, with typical bostrichid profile. Both adults and larvae feed on starchy dried cassava roots.

In the adult beetles, eyes (Fig. 4a) appear marginally detached, upraised and placed on the posterior end of the head (Beiriger 2010). Figure 4b shows the thorax side displaying elytron (dorsal surface) covered lightly with short reclining yellow hairs, are peculiar of *H. brunneus* (Fisher 1950, Walker 2005, Beiriger 2010). The pronotum (Fig. 5b) is much larger than the head (Fig. 5a); the clypeus is flat, and dense yellow hairs are present on the labrum (Fisher 1950). Smooth uneven granules on top of the pronotum (Beiriger 2010), two broadly separated parallel, identical, resembling hooks in front of the pronotum are some of the key features of the species. The sexes of the species are difficult to distinguish based on secondary sexual characteristics. Fisher (1950) states that in the extreme form males have strongly hooked, and a narrowly separated pair of teeth on the anterior margin of the pronotum, whereas female teeth are smaller, straight, and widely separated. However, there are all kinds of variations in between these two extreme forms. To accurately identify the sex of the species, dissecting the specimens and examination of internal genitalia is the only way.

The 658bp long partial sequence of the COI gene of *H. brunneus* was deposited under BOLD Systems database accession number BankIt1918662 CPETH001-16.COI-5P KX232682 (BoldSystems 2016).

Symptoms of Infestation and Management

Cassava tubers in southern Ethiopia are harvested during the dry season (October–February), peeled, chopped into thick slices (2–5 cm) and sun-dried (final moisture content 10–12%). Sun-dried cassava is stored in large quantities until further processing into the composite flour with teff (*Eragrostis tef*) and maize to prepare staple flat bread (Injera). During the survey, 100% of the wholesalers at Sodo and Bale town who were storing cassava for three and more months reported this particular beetle and its larvae as a destructive pest resulting in quantitative and qualitative losses. Turning cassava into powdery dust (Supp. Video S1 and S2 showing adult and larvae respectively feeding on dry cassava), representative entry holes and empty inner spacing were the common symptoms of *H. brunneus* presence. During the cassava (chips and chunks) store inspections at Sodo and Bale, it was observed that the powdery dust and empty inner spacing of cassava were providing a habitat for other grain and flour beetles as well as fungi.

Typical *H. brunneus* bores on dried cassava were about 3–4 mm diameter, illustrated in Figure 6a. Figure 6b shows a common cassava storage system, where cassava chips are filled in polypropylene bags and kept inside or under a roof to protect them from rain.

The common insecticides which were used by traders at the study locations to control *H. brunneus* and other storage insects were Malathion 5% Dust (active ingredient 50g/kg) and Celphos tablets (Aluminium phosphide fumigant insecticide). The presence of *H. brunneus* was reported year round, with not much difference from rainy to the dry season.

Conclusion

Incomplete information is available about the spread and distribution of *H. brunneus* globally. However, the current distribution based on published literature is largely limited to sub-Saharan Africa. Evidence suggests that there is a potential threat that the species may get introduced to and established in other parts of the world through global trade in wood and wood product. Along with its pest status of Wood, *H. brunneus* can be considered as a serious storage pest for dried starchy food products such as cassava. Further studies on damage assessments and sustainable control measures for the species are required in the survey area.

Supplementary data

Supplementary data are available at *Journal of Insect Science* online

Acknowledgments

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