

Late Pliocene of Fossil *Calosoma* (Coleoptera, Carabidae) from the Koka Formation, Kobiwako Group in Shiga Prefecture, Japan

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Abstract A fossilized elytron of the carabid beetle was discovered from the stratum of the Late Pliocene of the Kobiwako Group in the bed of the Yasu River, Shiga Prefecture, Japan. The fossil is identified as the genus *Calosoma*, and is recorded from the Kobiwako Group for the first time. This species is most similar to *Calosoma* (*Chrysostigma*) *calidum*, which is currently distributed in northern North America and has not been found from Japan. The biogeographical significance of its discovery from the stratum of the Late Pliocene of Japan is discussed.

Introduction

The genus *Calosoma* WEBER, 1801* contains 84 (ERWIN, 2007) or 128 (BRUSCHI, 2013) extant species, distributed in nearly all the regions of the world excepting equatorial Southeast Asia and Polar Regions. They are carnivores, prefer to feed on caterpillars and pupae of Lepidoptera. Unlike the sister group, *Carabus* (s. lat.), most species of *Calosoma* have well-developed hind wings and can fly. In some cases they fly long distances across the ocean (BRUSCHI, 2013). In Japan, four species of *Calosoma* have been recorded, that is, *Calosoma* (*Calosoma*) *maximowiczii* (MORAWITZ, 1863), *C. (C.) inquisitor cyanescens* MOTSCHULSKY, 1859, *C. (Campalita) chinese* (KIRBY, 1818), and *C. (Charmosita) lugens* (CHAUDOIR, 1869), though the records of the last species from Japan are highly disputable.

In 23 February 2016, a fossilized *Calosoma* beetle was obtained from the Koka Formation, Kobiwako Group in Shiga Prefecture, Japan by the second author. Although not a few fossil insects have been reported from the Kobiwako Group, most of them have been left unscrutinized (OKUYAMA, 1981; TOMINAGA and Insect Fossil Research Group, 1993; MORI, 1996; HAYASHI & SHIYAKE, 2002; HAYASHI, 2006; YAHIRO & HAYASHI, 2014, 2015, 2017). In this paper, the fossilized *Calosoma* beetle is described and its biogeographical significance is discussed.

Geological Setting

The Kobiwako Group is subdivided into eight formations: Ueno, Iga, Aoyama, Koka, Gamo, Kusatsu, Katata and Takashima, in ascending order (KAWABE, 1989, 1990, 1994).

The Koka Formation, which comprises the middle part of the Kobiwako Group, is distributed around the study area. The Kosaji volcanic ash bed is intercalated in the upper most part of this formation, and is approximately 2.6 Ma (million years ago) (SATOGUCHI & NAGAHASHI, 2012).

* In this paper, we interpret the genus *Calosoma* in a broad sense, though it has been used in a narrow sense by the past representative Japanese authors such as NAKANE (1962) and ISHIKAWA (1985).

The fossil was discovered from the riverbed of Yasu River, Yoshinaga, Konan City, Shiga Prefecture, Japan (Fig. 1). In this area, the upper most part of the Koka Formation is distributed along the Yasu River (Research Group for the Fossil Footprint at the River Yasu, 1998). The formation mainly contains gravels, sands and silts, but also interbedded volcanic ashes and lignite beds.

Methods and Materials

The fossil specimen was found by splitting rocks and using an eyeletor to examine the resulting surfaces. Rock samples containing fossils were immersed in ethyl alcohol in closed containers. The specimen was examined and photographed using a stereoscopic microscope. The fossil specimen reported in this paper is deposited in the collection of the second author.

Description of the Fossil

Family **Carabidae**

Subfamily **Carabinae**

Genus *Calosoma* WEBER, 1801

Calosoma (s. lat.) aff. *calidum* (FABRICIUS, 1775)

(Fig. 2)

Specimen examined. A piece of left elytron, generally well-preserved though lacking the basal part and several parts of apical-lateral margin, with the size 12.4×5.0 mm; color black; outer margin metallic green with a bluish tinge; primary foveae emerald blue; outer margin gently rounded in front, rather acutely and sinuously narrowed toward apex which is rather sharply pointed; sculpture triploid homodyname, all the three intervals almost equal in width and equally convex, with surface densely and remarkably notched transversely; primary intervals rather regularly but sparsely interrupted by large, and shallow primary foveae invading the adjacent tertiaries.

Remarks. This species is most similar to *Calosoma (Chrysostigma) calidum* (FABRICIUS, 1775), in common with the structure of elytron (sculpture triploid homodyname, all the three intervals almost equal in width and equally convex, with the surface densely and remarkably notched transversely). In comparison with the specimen of the extant *C. calidum* (Fig. 3; collecting data: Canada MB 4 km S-Aweme, 13.VI.2009), the fossil is a little different in having the following characters: 1) apical part of elytron more acutely narrowed toward apex which is more sharply pointed; 2) elytral margin more widely rimmed with a metallic color; 3) primary foveae more sparsely and a little more regularly set. Taking individual and geographical variations into account, however, it seems most similar to *C. calidum*, but we cannot determine it at the species level because the fossil specimen lacks many characters indispensable for correct identification.

Discussion

Calosoma (s. lat.) aff. *calidum* is recorded from the Kobiwako Group for the first time. *Calosoma calidum* is distributed in the northern North America (southern Canada and northeastern USA) (BRUSCHI, 2013), and has never been found not only from Shiga Prefecture but from Japan and the surrounding area (Shiga Carabidological Research Group, 2003; ISHIKAWA, 1985; BRUSCHI, 2013). It is assumed that the species once inhabited Japan in the Late Pliocene, but later it became extinct for

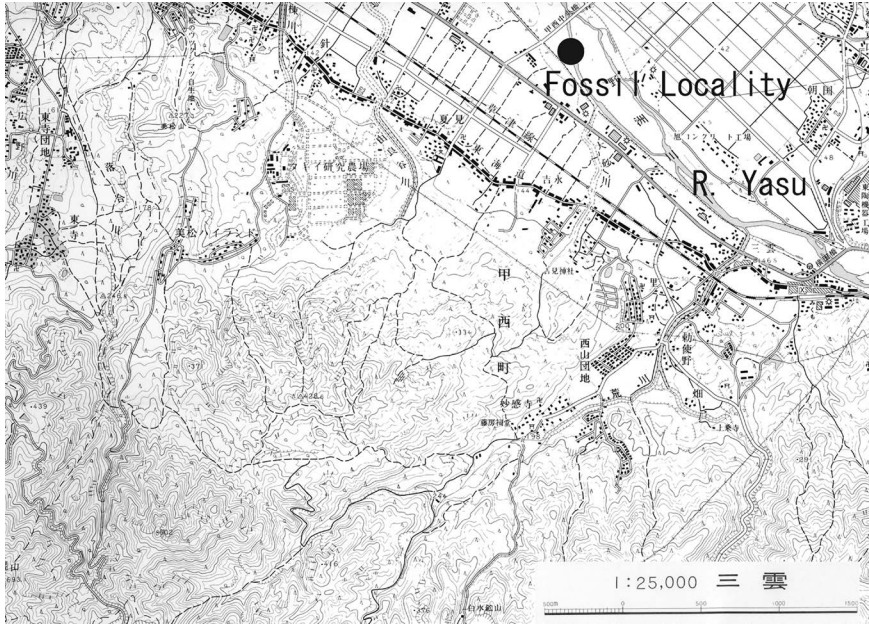


Fig. 1. Map showing the fossil locality in the Yasu River. Using the topographic maps “Mikumo”, scale 1 : 25,000 by the Geographic Survey Institute, Japan.



Fig. 2. Fossil of the left elytron of *Calosoma* (s. lat.) aff. *calidum* discovered from the stratum of the Late Pliocene of the Kobiwako Group in Shiga Prefecture, Japan. — A, Whole image; B, magnified image of median portion near sutural part; C, ditto of apical portion. Scale bars: 1.0 mm.

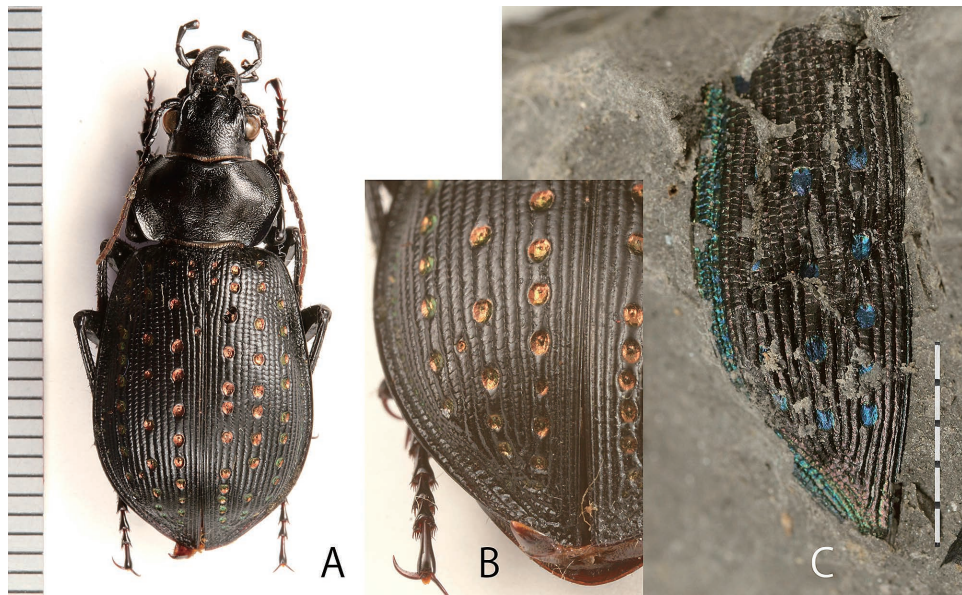


Fig. 3. *Calosoma (Chrysostigma) calidum* (A & B) and fossilized left elytron of *C. aff. calidum* (C) examined in this study. — A, Habitus of a recent specimen (Canada MB 4 kmS-Aweme); B, ditto (magnified view of left elytron). Scales shows 1.0 mm in A & C.

some reason. Extant species of beetles are recorded from the formation of the early Miocene and Pliocene (FIKÁČEK *et al.*, 2011; SCHWEIGERT, 2003).

In Japan, not a few carabine fossils have been recorded from the strata of the Late Miocene-Pliocene (FUJIYAMA, 1987; HAYASHI, 2001; HIURA, 1971; WATANABE & SHIYAKE, 2007), Early Pleistocene (HAYASHI, 1998), and Middle-Late Pleistocene (HAYASHI & MIYATAKE, 1996; Yokohama Middle Quaternary Research Team, 1987; HAYASHI, 1996, 1998, 2001; HAYASHI & TOMINAGA, 1995; HAYASHI *et al.*, 2004, 2005, 2008 a, b; AIBA, 2015; Fossil Insect Research Group for Nojiri-ko Excavation, 1984, 1987, 1990; Fossil Insect Research Group for Nojiri-ko Excavation and AKAGI, 1986; Kashiwazaki Naumann's Elephant Research Group, 1991; MATSUOKA *et al.*, 2000; Tado Collaborate Research Group, 1998; SHIYAKE, 2009; YAMAKAWA *et al.*, 2007) (Table 1).

Judging from these records, the carabine fauna of the Late Miocene-Pliocene (11.0 Ma–2.6 Ma) was different from that of the present one, though the state of preservation of most fossil materials is not necessarily good for discussing detailed changes of the Japanese carabine fauna. Early in the Pleistocene (2.6 Ma–0.8 Ma), the species still extant today already occurred and were coexisted with those now extinct in Japan. Therefore, it is presumed that the current carabine fauna of Japan had already been established by the Middle- to Late Pleistocene (0.8–0.01 Ma).

To clarify the transition of the Japanese carabine fauna across the ages, it is important to find well-preserved fossils from well-defined strata, and identify them as correct as possible.

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Table. 1. Records of fossil carabine beetles in Japan.

	Late Miocene-Pliocene	Early Pleistocene	Middle-Late Pleistocene	References
<Extant species>				
<i>Calosoma inquisitor</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1984)
<i>Calosoma maximowiczi</i>			●	AIBA (2015)
<i>Carabus vanvolxemi</i>			●	HAYASHI & MIYATAKE (1996), Yokohama Quaterna Research Team (1987), Fossil Insect Research Group for Nojiri-ko Excavation (1987)
<i>Carabus blaptoides</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1990), HAYASHI <i>et al.</i> (2008 b)
<i>Carabus granulatus</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1984, 1987), SHIYAKE (2009)
<i>Carabus albrechti</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1987, 1990)
<i>Carabus insulicola</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1984), Kashiwazaki Naumann Elephant Research Group (1991)
<i>Carabus arrowianus</i>			●	MATSUOKA <i>et al.</i> (2000)
<i>Carabus maeander</i>		●		HAYASHI (1998), HAYASHI & TOMINAGA (1995)
<i>Carabus maacki</i>		●	●	HAYASHI <i>et al.</i> (2005), HAYASHI (1998), Tado Collaborate Research Group (1998)
<Extinct species>				
<i>Calosomina</i> gen., sp.		●	●	HAYASHI (1996), Fossil Insect Research Group for Nojiri-ko Excavation & AKAGI (1986)
<i>Calosoma</i> sp.	●			FUJIYAMA (1987)
<i>Apotomopterus (Ohomopterus)</i> sp.	●			HIURA (1971)
<i>Calosoma</i> (s. lat.) aff. <i>calidum</i>	●			Present study
<Indetermined species>				
<i>Calosoma inquisitor?</i>		●		HAYASHI (1996, 2001)
<i>Carabus procerulus?</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1990)
<i>Carabus opaculus?</i>			●	Fossil Insect Research Group for Nojiri-ko Excavation (1990)
<i>Carabus japonicus?</i>			●	HAYASHI <i>et al.</i> (2005)
<i>Carabus</i> sp.			●	HAYASHI <i>et al.</i> (2004), HAYASHI <i>et al.</i> (2008 a), YAMAKAWA <i>et al.</i> (2007)
<i>Ohomopterus</i> sp.	●		●	HAYASHI (1996)
<i>Carabini</i> gen., sp.	●			WATANABE & SHIYAKE (2007)

要 約

八尋克郎・杉山國雄・林 成多：鮮新世後期の古琵琶湖層群甲賀層から産出したカタビロオサムシ属の化石（鞘翅目オサムシ科）。——滋賀県湖南市吉永の野洲川に分布する甲賀層から産出したオサムシ亜科の左鞘翅化石を調査した結果、広義のカタビロオサムシ属の一種 *Calosoma* sp. と同定され、上翅間室および孔点の形状等が現生種のなかでは *Calosoma (Chrysostigma) calidum* に最も似ていると判断された。*Calosoma calidum* は、現在では北米大陸のカナダ南部からアメリカ合衆国北東部にかけての地域に分布しており、我が国およびその周辺地域からは知られていない。現在の日本には、本化石に似た種は分布していないため、その後なんらかの理由で日本では絶滅したものと考えられる。本化石の発見は、鮮新世後期におけるオサムシ類の分布や成り立ちと、現代に至るまでの変遷を考察するうえで重要なものと言えよう。

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