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Takematsu, Yoko

Yamaoka, Ryohei

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Taxonomy of *Glyptotermes* (Isoptera, Kalotermitidae) in Japan with Reference to Cuticular Hydrocarbon Analysis as Chemotaxonomic Characters

Yoko TAKEMATSU

Institute of Tropical Agriculture, Kyushu University,
Fukuoka 8 12-8 1, Japan

and

Ryohei YAMAOKA

Department of Applied Biology, Kyoto Institute of Technology,
Matsugasaki Sakyo-ku, Kyoto 606, Japan

Abstract. The cuticular hydrocarbons of 4 species of *Glyptotermes* from Japan were identified using gas chromatography-mass spectrometry and the relative abundances of cuticular hydrocarbons were measured using mass spectrometry. It was found that *G. fuscus*, *G. satsumensis* and *G. nakajimai* have different hydrocarbon compositions, respectively, and that *G. kushimensis* has the same components as those of *G. nakajimai*. This suggests that *G. nakajimai* and *G. kushimensis* are the same species. Based on this results together with morphological observation, a new taxonomy of Japanese *Glyptotermes* is proposed, in which *G. kushimerzsis* and *G. kodamai* are synonymized with *G. nakajimai*.

Key words: Taxonomy, Isoptera, Kalotermitidae, *Glyptotermes*, Japan, cuticular hydrocarbon.

Introduction

The genus *Glyptotermes* Froggatt occurs in coastal areas along the Kuroshio and Tsushima currents in Japan and 5 species have so far been recorded: *G. fuscus*, *G. satsumensis*, *G. nakajimai*, *G. kodamai* and *G. kushimensis*. However, taxonomic positions of the last two species, *G. kodamai* and *G. kushimensis*, are still uncertain because they were only given simple and inadequate descriptions by Mori (1976, 1978). Indeed they are generally said to be very similar to *G. nakajimai*.

In this paper we reconsider the taxonomy of the genus *Glyptotermes* more rigorously based not only on the usual morphological observation but also on cuticular hydrocarbon analysis.

The taxonomic characters for distinguishing species based on morphology are indistinct, and it is difficult to distinguish species only by morphological characters.

Recent studies on the cuticular hydrocarbons have suggested that component of them would be a variable taxonomic character.

We analyzed the cuticular hydrocarbons of 4 species from Japanese *Glyptotermes*, and made a comparison of these components among them. From these results and morphological observations, we discussed the taxonomic position of Japanese *Glyptotermes* and made redescrptions.

Materials and Methods

Termites:

Termites for chemical analysis were collected from 4 different localities. We collected *G. fuscus* from Cape Sata (Kagoshima Pref.), *G. satsumensis* from Kagoshima City. *G. nakajimai* from Cape Ashizuri (Kochi Pref.) and *G. kushimensis* from Kushimoto (Wakayama Pref.) respectively. Other specimens using only morphological observations were reported in each description.

Chemical methods:

Cuticular hydrocarbons were extracted by immersing 10 to 15 workers in 2 ml of n-hexane for 5 min. The hexane extracts were evaporated to dryness and redissolved in 2 to 10 μ l of n-hexane for gas chromatography-mass spectrometry (GC-MS) and gas chromatography (GC).

GC-MS is used for qualitative analysis of cuticular hydrocarbons. It was performed on a Shimadzu QP1000EX mass spectrometer (Shimadzu, Kyoto, Japan). The gas chromatography was conducted by a Shimadzu 14A (Shimadzu, Kyoto, Japan) equipped with a fused-silica capillary column (Shimadzu CBP1-M25-025, film thickness 0.25 μ m). Ion-source temperature was 250°C, and the ionization energy was 70eV. The injection temperature was 300°C. Samples in 2 μ l of hexane were injected with a Grob type split less injector. The oven temperature was kept at 80°C for the first minute and then raised at 16°C/min to 300°C, and a final hold for 15min. The carrier gas (helium) velocity was ca. 40 cm/s.

GC is used for measuring of the relative abundance of each components. It was performed with a Shimadzu 14A gas chromatograph (Shimadzu, Kyoto, Japan), equipped with a flame ionization detector and the column and the conditions was same as GC-MS analysis. The even number of n-alkanes (n-C20 to n-C34) were used as standards to identify the analyzed cuticular hydrocarbons comparing with their retention times, equivalent chain length (ECL) and also mass spectra. The results were summarized by CHC-matrix (cuticular hydrocarbon component/ratio table).

Morphological observation:

Dissections and measurements were made in 80% alcohol. The relative size and proportion of the body parts are the important characters for the taxonomy of termites. The measurements, indices and their abbreviations are as follows: Head length without mandibles (HL) [S,A]; Maximum width of head (HW) [S,A]; Left mandible length (LML) [S]; Labrum length (LL) [S,A]; Labrum width (LW) [S,A]; Maximum height of head (HH) [S,A]; Number of antennal segments (A) [S,A]; Length of postmentum

Table 1. Cuticular hydrocarbons identified from 4 Japanese species of *Glyptotermes*.

| Peak No. | Hydrocarbons | ECL | <i>fuscus</i> | <i>satsumensis</i> | <i>nakajimai</i> | <i>kushimensis</i> |
|----------|---------------|-------|---------------|--------------------|------------------|--------------------|
| 1 | n-C21 | 21.00 | 0.38 | 5.16 | 0.73 | 1.13 |
| 2 | 11-meC21 | 21.38 | - | 0.64 | - | - |
| 3 | 2-meC21 | 21.63 | - | 0.43 | - | - |
| 4 | n-C22 | 22.00 | 0.50 | 0.57 | 0.76 | 0.92 |
| 5 | 3,7-dimeC21 | 22.09 | 0.59 | - | - | - |
| 6 | C22:2(coj) | 22.36 | - | 0.48 | - | - |
| 7 | 2-meC22 | 22.68 | 0.88 | 0.84 | 3.62 | 4.23 |
| 8 | 3-meC22 | 22.72 | 0.66 | 0.48 | - | - |
| 9 | C23:3 | 22.86 | - | 0.45 | - | - |
| 10 | n-C23 | 23.00 | 3.83 | 8.88 | 17.58 | 14.73 |
| 11 | 7-meC23 | 23.23 | 0.42 | - | - | - |
| 12 | C23:2(coj) | 23.27 | - | 3.64 | - | - |
| 13 | 9-,11-meC23 | 23.32 | - | - | 2.76 | 3.44 |
| 14 | C23:2(coj) | 23.50 | - | 18.07 | - | - |
| 15 | 2-meC23 | 23.68 | 0.72 | 3.57 | 1.82 | 2.15 |
| 16 | 3-meC23 | 23.77 | 0.67 | 1.74 | 2.64 | 2.47 |
| 17 | n-C24 | 24.00 | 1.41 | - | 1.73 | 2.21 |
| 18 | C23:3(coj) | 24.05 | - | 1.34 | - | - |
| 19 | 3,9-dimeC23 | 24.15 | 0.68 | - | - | - |
| 20 | C23:3(coj) | 24.20 | - | 0.92 | - | - |
| 21 | 11-meC24 | 24.35 | - | - | 1.83 | 2.09 |
| 22 | C24:2(coj) | 24.40 | - | 0.68 | - | - |
| 23 | C23:3(coj) | 24.55 | - | 1.08 | - | - |
| 24 | 2-meC24 | 24.70 | 1.74 | 1.04 | 2.36 | 5.73 |
| 25 | C25:3 | 24.85 | 0.88 | - | - | - |
| 26 | C25:3 | 24.95 | 0.74 | 0.27 | 0.49 | 1.11 |
| 27 | n-C25 | 25.00 | 4.04 | 1.92 | 6.36 | 6.27 |
| 28 | 9-,11-meC25 | 25.40 | 8.66 | - | - | - |
| 29 | 10,12-dimeC25 | 25.45 | - | - | 14.86 | 15.95 |
| 30 | C25:2(coj) | 25.50 | - | 5.68 | - | - |
| 31 | 2-meC25 | 25.65 | 0.74 | 0.96 | - | - |
| 32 | undetermined | 25.73 | - | - | 1.76 | 1.64 |
| 33 | 3-meC25 | 25.75 | 1.44 | 0.84 | 1.03 | 0.91 |
| 34 | C25:3(coj) | 26.05 | 2.02 | 1.22 | 2.17 | 3.17 |
| 35 | C25:3(coj) | 26.21 | 1.37 | - | 1.14 | 0.69 |
| 36 | 13-meC26 | 26.37 | - | - | 1.30 | 1.28 |
| 37 | 12-meC26 | 26.42 | 2.30 | - | - | - |
| 38 | C25:3(coj) | 26.58 | 1.48 | 0.90 | 2.22 | 1.64 |
| 39 | C27:1 | 26.74 | 2.27 | - | 1.57 | 1.37 |
| 40 | n-C27 | 27.00 | 1.53 | 1.26 | 1.47 | 1.01 |
| 41 | 11-,13-meC27 | 27.37 | 1.00 | 1.07 | 2.17 | 2.28 |
| 42 | undetermined | 27.53 | 12.82 | - | - | - |
| 43 | 10,12-dimeC27 | 27.63 | - | - | 1.88 | 0.99 |
| 44 | n-C28 | 28.00 | - | - | 0.73 | 0.53 |
| 45 | 13-meC28 | 28.32 | 1.11 | - | - | - |
| 46 | n-C29 | 29.00 | 1.19 | 0.99 | - | - |
| 47 | 11-,13-meC29 | 29.27 | - | 0.59 | - | - |

(PmL) [S]; Maximum width of postmentum (PmW1) [S]; Minimum width of postmentum (PmW2) [S]; Maximum length of pronotum (PnL)[S,A]; Maximum width of pronotum (PnW)[S,A]; Compound eye diameter (CD) [A]; Cephalic index (HL/HW) [S,A]; Mandibular index (LML/HL) [S]; Compound eye index (CD/HH) [A]; Labrum index (LL/LW) [S]; Postmentum index (PmW2/PmW 1) [S]. The applications for castes of above measurements and indices are shown in square brackets: S, soldiers; A, alates.

Results and Discussion

We have analyzed the cuticular hydrocarbons of 4 *Glyptotermes* species in Japan, and separated them into 3 phenotypes according to the cuticular hydrocarbon composition.

The gas chromatograms of cuticular hydrocarbons of 4 species of *Glyptotermes* are shown in Fig. 1. Chain length of cuticular hydrocarbons of this genus ranged from C2 1 to C29. The components and their relative abundances in each species are presented in Table. 1.

The components sharing with all the Japanese species were as follows: (14 components) n-C2 1, n-C22, 2-meC22, n-C23, 2-meC23, 3-meC23, 2-meC24, C25:3, n-C25, 3-meC25, C25:3(coj), n-C27, 1 1-meC27 and 13-meC27.

The each species is characterized below.

G. fuscus

This species had the following unique components in relatively high proportions (1% or more): 9-, 1 1-meC25 (8.66%), 12-meC26 (2.30%), 13-meC28 (1.11%) and one undetermined substance (ECL=27.53) (12.82%). The following components were also characteristic to this species, but rather rare (less than 1 %): 3,7-dimeC21, 7-meC23, 3,9-dimeC23.

G. satsumensis

The unique components of this species in relatively high proportions were C23:2(coj) (3.64%), 18.07%), C23:3(coj) (1.34%), and C25:2(coj) (5.68%). The following components were also characteristic to this species, but rather rare (less than 1 %): 11-meC21, 2-meC21, C22:2(coj), C23:3, C24:2(coj), 1 1-, 13-meC29.

G. nakajimai and *G. kushimensis*

The cuticular hydrocarbons of these two species were the same in composition, although relative percentage of abundance was different. The unique components of these species in relatively high proportions were as follows: 9-, 1 1-meC23 (2.76, 3.44%), 11-meC24 (1.83, 2.09%), 10,12-dimeC25 (14.86, 15.95%), 10,12-dimeC27 (1.88, 0.99%), 13-meC26 (1.30, 1.28%), n-C28 (0.73, 0.53%) and one undetermined substance (ECL=25.73) (1.76, 1.64%) (percentage of *nakajimai*, *kushimensis*, respectively).

Many studies have shown that the hydrocarbon compositions of termites are different between species (Howard, 1993). These results thought to be applied for distinguishing and identifying species.

TAXONOMY OF *GLYPTOTERMES*

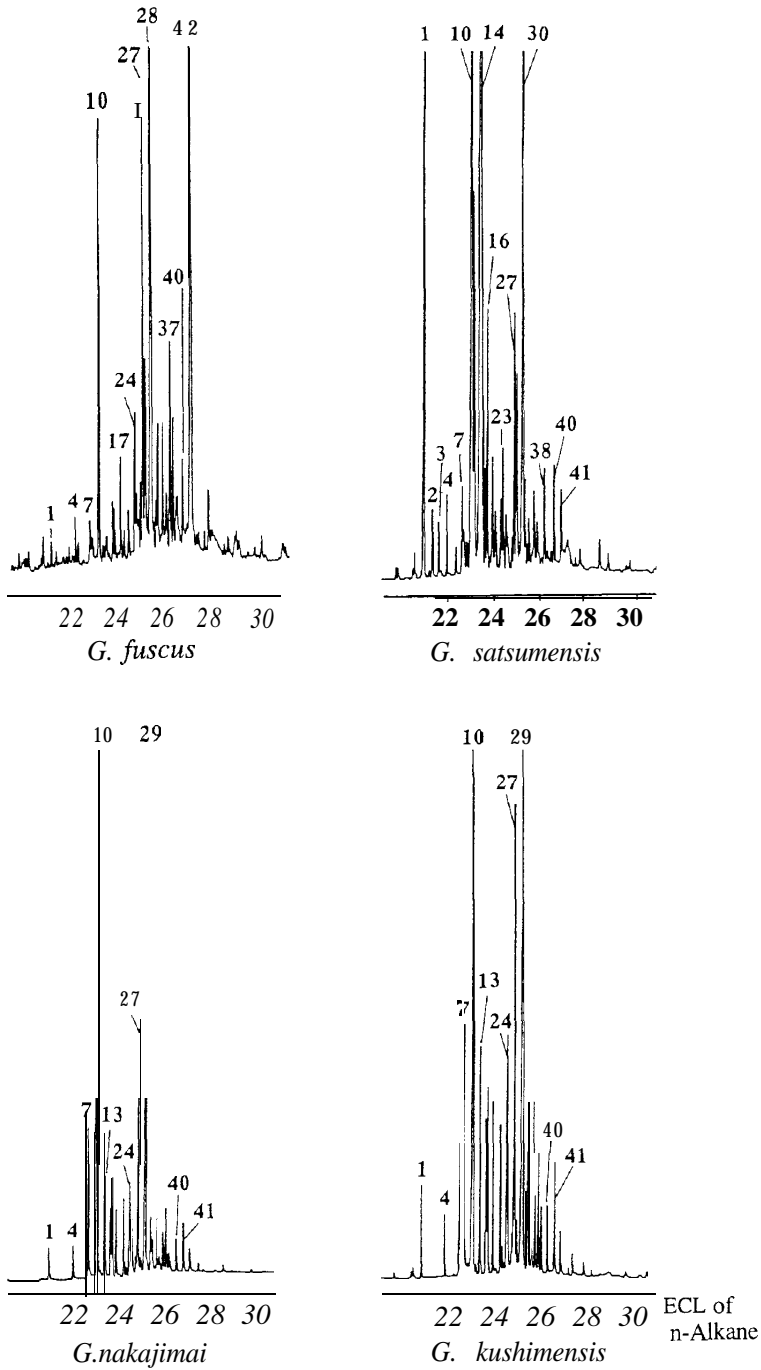


Fig. 1. Total ion chromatograms of cuticular hydrocarbons derived from 4 Japanese species of *Glyptotermes*.

G. juscus, *G. satsumensis* and *G. nakajimai* have different hydrocarbon compositions quantitatively and qualitatively. *G. kushimensis* has the components that is the same with *G. rzakajimai* qualitatively. This result suggests that *G. fuscus*, *G. satsumensis* and *G. nakajimai* can be treated as full species but *G. nakajimai* and *G. kushimensis* belong to the same species.

From the morphological point of view, Mori (1976, 1978) noted the rapid slope of frons, proportion of head width and thicker head height as their taxonomic characters. Though we had no chance to examine any types of *G. kodamai* and *G. kushimensis*, these 2 species can be placed within the range of variation of *G. nakajimai* in these morphological characters. Moreover, these 3 species can be captured in the same tree at a time, and also in the dead tree in which the type colony of *G. kushimensis* at Kushimoto, Wakayama Pref. was collected.

Judging from the results of chemical analysis and morphological observation, the justification of *G. kushimensis* and *G. kodamai* as a good species is doubtful. We treat these 2 species as synonyms of *G. nakajimai*. The detailed descriptions are made in the taxonomic section.

Taxonomy

Genus *Glyptotermes* Froggatt

Glyptotermes Froggatt, 1896, Proc. Linnean Soc. New South Wales, 21: 543. Type-species: *Glyptotermes tuberculatus* Froggatt.

Glyptotermes fuscus Oshima, 19 12

[Japanese name: Katan-shiroari]

(Figs. 2-5)

Glyptotermes fuscus Oshima, 1912, p.67, (type-locality: Taiwan) – Krishna, 1961, p.348 – Tsai & Chen, 1964, pp.5 1-52 – Tsai & Huang, 1980, p. 15 – Morimoto, 1980, p.27 – Huang *et al.*, 1989, pp.158-159.

Calotermes (Glyptotermes) fuscus: Oshima, 1913, p.274 – Oshima, 1914, p.2 – Hozawa, 1915, pp.42-51.

Calotermes (Glyptotermes) Hozawae Holmgren, 1912, p. 118 – Holmgren, 19 13, p.53.

Alates: Head capsule dark brown. Antennae and mandibles pale brown; teeth darker. Pronotum dark brown as head. The rest of body brownish. Wing membrane brown and hyaline, veins dark brown. Legs pale brown, tibia and tarsus paler.

Head capsule oval, with several long and short hairs; cephalic index 0.9 I-0.97. Compound eyes large, slightly longer than wide, 0.23-0.25 mm in diameter; compound eye index 0.42-0.45. Ocelli distinct, almost one fourth of compound eyes in diameter. Antennae with 11-13 segments. Labrum with several long hairs at anterior margin and short hairs on anterior surface. Left mandible with apical tooth slightly longer than 1st + 2nd marginal tooth; posterior margin of 1st + 2nd marginal tooth longer than its anterior margin, and posterior base of 1st + 2nd marginal tooth without notch. Right mandible

with apical tooth as long as 1st marginal tooth; posterior margin of 2nd marginal tooth longer than molar plate. Postmentum rectangular, distinctly longer than wide. with slightly converging anteriorly at sides, and convex at posterior margin; lateral margins bearing with many short hairs and several long ones; surface bald.

Pronotum simple and flat, as wide as head, weakly concave but not notched in the middle of anterior margin, weakly concave at posterior margin; with many short hairs and several long hairs on disc, which are abundant on sublateral and marginal portions.

Fore wings 5.85-6.15 mm long; radius meeting costa at anterior one sixth of costal margin; radial sector without branches, parallel to costal margin; media running close and parallel to radial sector, reaching apex, with a few weak transverse veins to radial sector in distal half; cubitus weak and unsclerotized, with 10-14 branches to posterior margin. Hind wing slightly shorter than fore wing; media raised from radial sector at its anterior one fourth, running close to radial sector, meeting radial sector at distal one fifth, reaching apex; cubitus weak and unsclerotized, with 10-13 branches to posterior margin. Femur/tibia index 0.72-0.73; tibia! spurs 3:3:3.

Measurements (mm). HL 0.80-0.88 (0.84); HW 0.88-0.90 (0.89); LL 0.23-0.25 (PnL4); LW 0.22-0.24 (0.03); HH 0.50-0.60 (0.56); 5 4) ; PnW 0 . 8 3 - 0.85 (0.84) ($n=15$).

Soldiers: Head capsule reddish brown, darker anteriorly, paler dorsally; clypeus reddish brown as head; labrum reddish brown as head; antennae brownish yellow; mandibles dark brown. Thorax and abdomen brownish yellow.

Head capsule short and phragmotic; subrectangular, with slightly converging sides anteriorly, with posterior margin rounded, with several hairs sparsely; cephalic index 1.12-1.34; frontal area sloping quite steeply to vertical, bilobed; epicranial and frontal sutures faint. Antennae with 10-11 segments. Labrum slightly longer than wide. rounded at anterior margin, parallel at lateral sides, with several long hairs on anterior margin and a few short hairs on surface. Mandibles short and robust; weakly humped at base, with many short hairs; mandibular index 0.43-0.55. Left mandible with posterior base of 2nd marginal tooth without notch. Right mandible with both anterior and posterior base of 1st marginal tooth without notch. Postmentum club-shaped: slightly concave at lateral sides; widest at anterior one third and narrowest at posterior one third. with several hairs.

Pronotum flat, as wide as or slightly wider than head; faintly concave and not notched in the middle of anterior margin, with several long and short hairs on surface and with many long and short hairs at margins. Femur/tibia index 0.90-0.96; tibia1 spurs 3:3:3. *Measurements* (mm). HL 1.03-1.27 (1.18); HW 0.92-0.97 (0.94); LML 0.53-0.57 (0.56); LL 0.22-0.23 (0.23); LW 0.19-0.20 (0.20); HH 0.77-0.83 (0.80); PmL 0.83-0.93 (0.88); PmW1 0.37-0.40 (0.38); PmW2 0.23-0.27 (0.26); PnL 0.57-0.60 (0.58); PnW 0.90-1.00 (0.95) ($n=10$).

Materials examined. Okinoshima Is., Kochi Pref., 1992/11/15, Takematsu leg., 2 colonies (SW); Kagoshima City, Kagoshima Pref., 1992/10/28, Takematsu leg. (SW); Cape Sata, Kagoshima Pref., 1992/5/20, Takematsu leg. (SWA) -1992/10/29, Takematsu leg. (SW); Gamouzaki, Amami-Oshima Is., 1993/4/25, Takematsu leg. (SW); Ishigaki Is., Ryukyus, 1991/10/26, Takematsu leg. (SW) -1992/8/4, Takematsu leg. (SW) (all deposited in KU).

Distribution. Japan (Izu Peninsula, Kii Peninsula, Kochi Pref., Ohita Pref., Miyazaki Pref., Nagasaki Pref., Kumamoto Pref., Kagoshima Pref., Ryukyus); Taiwan; Southern China.

Remarks. This species usually nests in the trunks of alive wood. It swarms in the evening in June. Hozawa (1915) might be confused fuscus with nakajimai. His figure of soldiers in Text-fig.10 (p.49, 1915) is apparently nakajimai, but the figure in pl. II, fig.8 (1915) may be the true fuscus. Furthermore, he noted that the specimens from Ogasawara Isls. were somewhat different from those from Taiwan. These results suggest that the some records of his fuscus may include nakajimai.

Glyptotermes satsumensis (Matsumura, 1907)

[Japanese name: Satsuma-shiroari]

(Figs. 6-9)

Termes satsumensis Matsumura, 1907, p.53, (type-locality: Kagoshima, Japan).

Termes sp.: Matsumura, 1904, p.24.

Calotermes sp.: Shiraki, 1909, pp.24 1-242.

Calotermes koshunensis: Oshima (*nec* Shiraki), 191 lb, pp.360-361.

Cnlotermes (Glyptotermes) satsumensis: Holmgren, 1912, p.116 – Holmgren. 1913, p.57 – Oshima, 1914, p.1 – Hozawa, 1915, pp.33-42.

Glyptotermes longicephalus Oshima, 19 12, p.64.

Glyptotermes satsumensis: Snyder, 1949, p.51 – Krishina, 1961, 348 – Tsai & Chen. 1964, pp.52-53 – Tsai & Huang, 1980, p.15 – Morimoto, 1980, p.28 – Huang et al., 1989, pp.134-135.

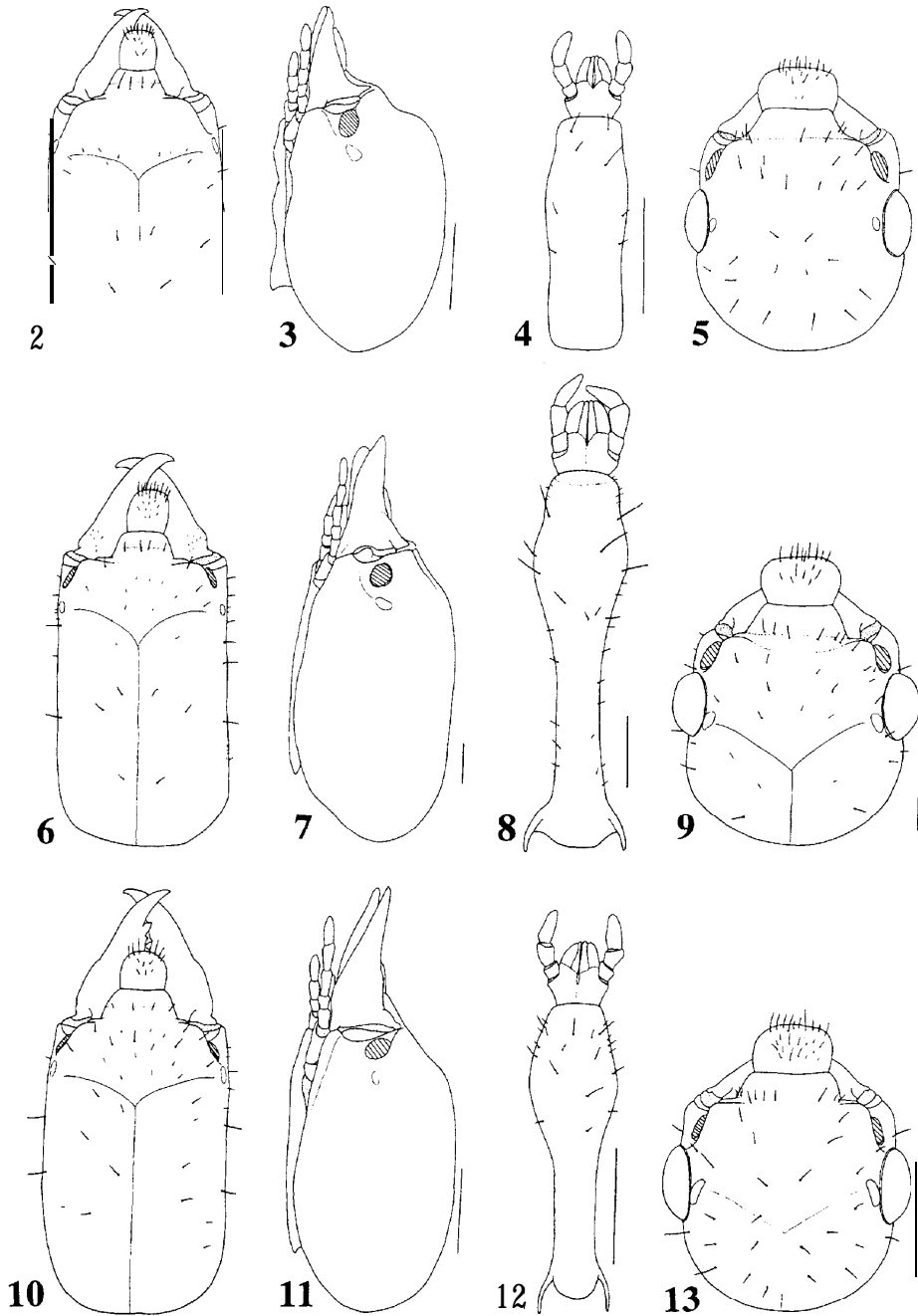
Alates: Head capsule, Antennae and mandibles brownish yellow; teeth darker. Pronotum brownish yellow as head. The rest of body brownish yellow: sterna paler. Wing membrane brownish yellow and hyaline, veins light brown. Legs brownish yellow.

Head capsule oval, sparsely with short hairs; cephalic index 0.89-0.9 1. Compound eyes large, slightly wider than long, 0.35-0.40 mm in diameter; compound eye index 0.39-0.44. Ocelli distinct, almost one third of compound eyes in diameter. Antennae with 14-17 segments. Labrum with several long and short hairs at anterior margin and short hairs on anterior surface. Left mandible with apical tooth longer than 1st + 2nd marginal tooth; posterior margin of 1st + 2nd marginal tooth longer than its anterior margin, and posterior base of 1st + 2nd marginal tooth distinctly notched. Right mandible with apical tooth as long as 1st marginal tooth; posterior margin of 2nd marginal tooth longer than molar plate. Postmentum rectangular, distinctly longer than wide, slightly converging anteriorly at sides, and convex at posterior margin. with many short and several long hairs at lateral margins; surface with several short hairs on anterior half and with several minute hairs on posterior portions.

Pronotum simple and flat, as wide as head, weakly concave but not notched in the middle of anterior margin, weakly concave at posterior margin, with several short hairs on disc and with many short and long hairs on marginal portions.

Fore wings 9.60-9.90 mm long; radius meeting costa at anterior one fourth of costal margin; radial sector without branches, parallel to costal margin; media running close

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Figs. 2-13. Japanese *Glyptotermes*. — 2-5, *G. fuscus*; 6-9, *G. satsumensis*; 10-13, *G. nakajimai*; 2,6,10, solider, head, dorsal view; 3,7,11, ditto, lateral view; 4,8,12, solider, postmentum; 5,9,13, alate, head, dorsal view. Scales, 0.5 mm.

and parallel to radial sector, reaching apex, with several weak transverse veins to radial sector in distal one third; cubitus weak and unsclerotized, with 10-11 branches to posterior margin. Hind wings slightly shorter than fore wings; media raised from radial sector at its anterior one fifth, running close to radial sector, reaching apex: cubitus weak and unsclerotized, with 10-11 branches to posterior margin. Femur/tibia index 0.78-0.83; tibial spurs 3:3:3.

Measurements (mm). HL 1.28-1.38 (1.32); HW 1.40-1.53 (1.47); LL 0.38-0.40 (0.40); LW 0.50-0.52 (0.51); HH 0.85-0.90 (0.89); PnL 0.73-0.85 (0.80); PnW 1.33-1.45 (1.38) ($n=12$).

Soldiers: Head capsule reddish brown, darker anteriorly, paler dorsally; anteclypeus whitish; postclypeus reddish brown as head; labrum yellowish brown; mandibles dark brown. Thorax and abdomen brownish yellow.

Head capsule long, subrectangular, parallel at sides, with distinct anterolateral lobes at the base of mandibles, sparsely with long and short hairs; cephalic index 1.28-1.45; frontal area sloping gradually; epicranial and frontal sutures distinct. Antennae with 14-16 segments. Labrum longer than wide, arcuate at anterior margin, parallel at lateral sides, with several long hairs on anterior margin and several short hairs on surface. Mandibles short and robust; weakly humped at base, with many short hairs; mandibular index 0.46-0.56. Left mandible with both anterior and posterior bases of 2nd marginal tooth distinctly notched. Right mandible with both anterior and posterior base of 1st marginal tooth distinctly notched; posterior margin of 1st marginal tooth slightly longer than anterior margin. Postmentum long, club-shaped; anterior half concaved laterally, widest at anterior one third, bearing with several long hairs on lateral portions; posterior half narrowest, parallel at lateral sides, with many short hairs at lateral margins.

Pronotum flat, as wide as head, concave and not notched in the middle of anterior margin, with a few hairs on surface and with many long hairs at margins. Femur/tibia index 0.83-0.90; tibial spurs 3:3:3.

Measurements (mm). HL 1.95-2.80 (2.37); HW 1.40-1.92 (1.75); LML I .00-1.30 (1.22); LL 0.29-0.48 (0.35); LW 0.38-0.55 (0.51); HH 1.23-1.73 (1.50); PmL 1.60-2.63 (2.04); PmW1 0.49-0.60 (0.56); PmW2 0.20-0.30 (0.27); PnL 0.65-1.06 (0.89); PnW 1.32-1.85 (1.68) ($n=20$).

Materials examined. Cape Ashizuri, Kochi Pref., 1992/11/14. Takematsu leg., 5 colonies (SW); Kagoshima City, Kagoshima Pref., 1992/12/20. Kodama leg. (SW); Cape Sata, Kagoshima Pref., 1991/4/28, Takematsu leg., 10 colonies (SWA) - 1992/10/29, Takematsu leg. (SW) (all deposited in KU).

Distribution. Japan (Kochi Pref., Miyazaki Pref., Kagoshima Pref., Nakanoshima Is.); Taiwan; Southern China.

Remarks. This species usually nests in the trunks of alive wood. It swarms in the evening in June to July. Seemingly, the species is similar to *Neotermes koshunensis* among Japanese termites in having the similar shape of head in soldiers. It is distinguished from *N. koshunensis* by the following characters of the soldiers: distinct anterolateral prominences of the head; the smaller 3rd segment of the antenna compared with adjacent segments; distinctly swollen mesepimeron. In this species, the size variation of individuals in a colony is great.

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Glyptotermes nakajimai Morimoto, 1973

[Japanese name: Nakajima-shiroari]

(Figs. 10-13)

- Glyptotermes nakajimai* Morimoto, 1973, pp.470-474, (type-locality: Cape Ashizuri, Kochi, Japan) – Morimoto, 1980, p.28 – Nishiharu & Sasaji, 1994, pp.61-62.
Glyptotermes kushimensis Mori, 1978, p.34, (type-locality: Kushimoto, Wakayama Pref., Honshu) – Morimoto, 1980, p.28. **n. syn.**
Glyptotermes kodamai Mori, 1976, p.54, (type-locality: Kushima City, Miyazaki Pref., Kyushu) – Morimoto, 1980, p.28. **n. syn.**

Alates: Head capsule dark brown. Antennae and mandibles pale brown; teeth darker. Pronotum dark brown as head. The rest of body brownish. Wing membrane brown and hyaline, veins dark brown. Legs pale brown, tibia and tarsus paler.

Head capsule oval, with scattered hairs; cephalic index 0.94-0.98. Compound eyes large, slightly longer than wide, 0.29-0.30 mm in diameter; compound eye index 0.46-0.51. Ocelli distinct, almost one third of compound eyes in diameter. Antennae with 11-13 segments. Labrum with several long hairs at anterior margin and many short hairs on anterior surface. Left mandible with apical tooth longer than 1st + 2nd marginal tooth; posterior margin of 1st + 2nd marginal tooth longer than its anterior margin and anterior margin of 3rd marginal tooth; posterior base of 1st + 2nd marginal tooth weakly notched. Right mandible with apical tooth as long as 1st marginal tooth; posterior margin of 2nd marginal tooth almost as long as molar plate. Postmentum rectangular, distinctly longer than wide, converging anteriorly at sides, and convex at posterior margin. with many short and several long hairs on surface, which are denser at lateral margins.

Pronotum simple and flat, as wide as head, weakly concave but not notched in the middle of anterior margin, weakly concave at posterior margin; with several short and a few long hairs on disc, and with many short and long hairs at margin.

Fore wings 6.80-7.10 mm long; radius meeting costa at anterior one third of costal margin; radial sector without branches, parallel to costal margin, with several weak transverse veins to costal margin in distal half; media running close and parallel to radial sector, reaching apex, with several weak transverse veins to radial sector in distal half; cubitus weak and unsclerotized, with 8-10 branches to posterior margin. Hind wing slightly shorter than fore wing; media raised from radial sector at its anterior one fifth, running close to radial sector, reaching apex; cubitus weak and unsclerotized. with 6-7 branches to posterior margin. Femur/tibia index 0.79-0.81; tibial spurs 3:3:3.

Measurements (mm). HL 0.96-1.01 (0.99); HW 1.03-1.05 (1.04); LL 0.28-0.32 (0.30); LW 0.35-0.40 (0.36); HH 0.59-0.63 (0.60); PnL 0.55-0.60 (0.58); PnW 0.95-1.04 (1.00) ($n=20$).

Soldiers: Head capsule yellowish brown, darker anteriorly; antennae, labrum and clypeus yellowish brown as head; mandibles dark brown. Thorax and abdomen light brownish yellow.

Head capsule long, subrectangular, parallel at sides, without anterolateral lobes at the base of mandibles, with long and short hairs sparsely; cephalic index 1.14-1.46; frontal area sloping gradually; epicranial and frontal sutures distinct. Antennae with 10-13 segments. Labrum as long as wide, rounded at anterior margin, parallel at lateral sides. with several long hairs at anterior margin and several short hairs on surface. Mandibles

short and robust; faintly humped at base, with many short hairs; mandibular index 0.51-0.64. Left mandible with both anterior and posterior bases of 2nd marginal tooth distinctly notched. Right mandible with both anterior and posterior base of 1st marginal tooth distinctly notched; posterior margin of 1st marginal tooth distinctly longer than anterior margin. Postmentum long, club-shaped; anterior half concaved laterally, widest at anterior one third, bearing with several short and long hairs on surface: posterior half narrowest, parallel at lateral sides, bald.

Pronotum flat, as wide as head, concave and not notched in the middle of anterior margin, with several hairs on surface and with many short and long hairs at margins. Femur/tibia index 0.88-0.95; tibial spurs 3:3:3.

Measurements (mm). HL 1.17-1.50 (1.41); HW 0.92-1.13 (1.08); LML 0.70-0.93 (0.81); LL 0.13-0.25 (0.20); LW 0.23-0.32 (0.28); HH 0.77-1.03 (0.95); PmL 0.8% 1.47 (1.24); PmW1 0.37-0.48 (0.43); PmW2 0.14-0.20 (0.18); PnL 0.38-0.63 (0.58); PnW 0.80-1.12 (1.04) ($n=34$).

Materials examined. Hahajima Is., Ogasawara Isls., 1991/7/15. Nakamura leg. (SW): Chichijima Is., Ogasawara Isls., 1992/11/25, Takematsu leg.. 2 colonies (SW): Kushimoto, Wakayama Pref., 1991/10/8, Takematsu leg., 11 colonies (SW) -1992/4/2, Yoshino leg., 5 colonies (SW); Cape Ashizuri, Kochi Pref., 1990/9/29, Takematsu leg.. 5 colonies (SWA); Cape Sata, Kagoshima Pref., 1991/4/28, Takematsu leg. (WA) (all deposited in KU).

Distribution. Japan (Fukui Pref., Kii Peninsula, Kochi Pref., Ohita Pref., Miyazaki Pref., Kagoshima Pref., Amami-Oshima Is., Ogasawara Isls.).

Remarks. This species usually nests in the decayed logs or dead branches. Its swarm was recorded at daytime in March to May. Detailed discussion of treatment of this species has discussed above.

Key to the Japanese species of *Glyptotermes*

Alates

1. Color right brown; larger species, head width more than 1.40 *satsumensis*
Color dark brown; smaller species, head width 1.05 or less 2
2. Compound eyes relatively small, eyes 0.23-0.25 mm in diameter, compound eye index 0.42-0.45 *fuscus*
Compound eyes relatively large, eyes 0.29-0.30 mm in diameter. compound eye index 0.46-0.51 *nakajimai*

Soldiers

1. Head with distinct anterolateral lobes at base of the mandibles; larger species.
head width more than 1.40 mm *satsumensis*
Head without distinct anterolateral lobes at the base of the mandibles; smaller species, head width 1.13 mm or less * * * 2
2. Head short, head length 1.03-1.27 mm, phragmotic; posterior part of postmentum slightly narrower than anterior one *fuscus*

Head long, head length 1.17- 1 SO mm; postmentum club-shaped, posterior part distinctly narrower than anterior one*nakajimai*

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References

- Froggatt, W. W., 1896. Australian Termitidae. Part II. *Proc. Linn. Soc. New South Wales*, 21: 510-552.
- Holmgren, N., 1912. Die Termiten Japans. *Annot. Zool. Jpn.*, 8: 107-136.
- Holmgren, N., 1913. Termitenstudien. 4. Versuch einer systematischen Monographie der Termiten der orientalischen Region. *K. Svenska Vetensk. Akad. Handl.*, 50(2): 1-276.
- Howard, R. W., 1993. Cuticular hydrocarbons and chemical communication. In D.W. Stanley-Samuelson & D. R. Nelson (eds.), "Insect Lipids: Chemistry, Biochemistry and Biology", pp. 179-226, Univ. Nebraska Press.
- Hozawa, S., 1915. Revision of the Japanese termites. *J. Coll. Sci. Tokyo imp. Univ.*, 35(7): 1-82.
- Huang, F. S., G. X. Li & S. M. Zhu, 1989. *The Taxonomy and Biology of Chinese Termites -Isoptera-*. Tianze Press, Beijing, 605pp. (In Chinese)
- Krishna, K., 1961. A generic revision and phylogenetic study of the family Kalotermitidae (Isoptera). *Bull. Am. Mus. nat. Hist.*, 122: 303-408.
- Matsumura, S., 1904. *Sousand Insects of Japan*. Vol. 1, Tokyo. (In Japanese)
- Matsumura, S., 1907. *Systematic Entomology*. Tokyo. (In Japanese)
- Mori, H., 1976. News: *Glyptotermes kodamui* Mori, sp. nov. *Shiroari*, (25): 54. (In Japanese)
- Mori, H., 1978. Previous communication: *Glyptotermes kushimensis* Mori, sp. nov. *Shiroari*, (32): 34. (In Japanese)
- Morimoto, K., 1973. *Glyptotermes nakajimai*, a new termite from Japan. *Kontyû*, 41: 470-474.
- Morimoto, K., 1980. Termites. In "Shiroari Shosetsu", pp. 1-11. (In Japanese)
- Nishiharu, S. & H. Sasaji, 1994. Discovery of *Glyptotermes nakajimai* Morimoto (Isoptera) from Is. Aoshima, Fukui Pref., off the coast of the Japan Sea. *Ent. J. Fukui*, (15): 61-62. (In Japanese)
- Oshima, M., 1911. On the difference between *Leucotermes flaviceps*, n. sp. and *Leucotermes speratus* (Kolbe) and the specific name of the termites found in Japan proper. *Insect World*, 15: 355-363. (In Japanese)
- Oshima, M., 1912. *The Third Official Report on Termites*. Taihoku. (In Japanese)

- Oshima, M., 1913. Notes on the termites of Japan, with description of one new species. *Philippine J. Sci., sect. D*, 8: 271-280.
- Oshima, M., 1914. *The Fourth Official Report on Termites*. Taihoku. (In Japanese)
- Shiraki, T., 1909. On the Japanese termites. *Trans. Ent. Soc. Japan*, 2: 229-242. (In Japanese)
- Snyder, T. E., 1949. Catalog of the termites (Isoptera) of the world. *Smith. misc. Coll.*, 112: 1-490.
- Tsai, P. & N. Chen, 1964. *Economic Entomology in China. VIII. Termites*. 14 1 pp. (In Chinese)
- Tsai, P. & F. S. Huang, 1980. *The Chinese Termites*. 56pp. (In Chinese)