at the time of formation of leucogranite, and high Rb/Sr ratio suggests an upper continental crustal source for the leucogranite (Table 3). The tectono-magmatic discrimination diagram indicates that it is a syn-collisional to late orogenic granite[17] (Figure 4 *c*). The Ba–Rb–Sr discrimination diagram also indicates that it is a collisional granite[18] (Figure 4 *c*). The leucogranite is related to the collision between the Indian and Tibetan plates as evidenced by the Tertiary age.

Comparison with other leucogranites of the Higher Himalayas shows their similarity in mineralogy and geochemistry. All these leucogranites are tourmaline-bearing two-mica granites. Geochemically, these are characterized by high silica content (>69% SiO_2), high alkalis, depleted Ca, Mg and Mn, high Rb/Sr ratio, per-aluminous nature, similar age[11,19–21] and high initial $^{87}Sr/^{86}Sr$ ratios (Table 4). All these characteristics can be related to the melting of a sedimentary protolith. Radioelemental (U and Th) concentration is higher in the leucogranites of the Higher Himalaya than in normal granites, while radioelemental concentration in the granites of the study area is much higher (Table 4).

The preliminary data collected on the tourmaline-bearing leucogranites of the Higher Himalayas in a part of Arunachal Pradesh appear to be encouraging from the point of view of uranium mineralization and exploration.

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Nutritional value of representative termite species with an emphasis on *Odontotermes obesus* (Rambur)

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Dewinged termite imagoes are considered to be delicious human food around the world. The nutrient composition may vary with respect to the species. In the present study, imagoes of three termite species, viz. *Odontotermes obesus*, *Coptotermes heimi* and *Microtermes obesi* were used to compare their protein composition. Additionally, the commonest species, *O. obesus* was used for

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proximate and mineral composition analysis. The nutritional analysis of termites indicated a higher percentage of protein in *C. heimi*, followed by *O. obesus*. The proximate analysis of *O. obesus* imagoes revealed a higher proportion of crude fat followed by crude protein. Macrominerals were recorded in a higher proportion with potassium as one of the major minerals followed by sodium, while in microelements iron and zinc were represented in greater quantities.

Keywords: *Coptotermes heimi*, crude fat, edible protein, imagoes, *Microtermes obesi*, nutritional value, *Odontotermes obesus*.

IN Africa, Asia, Australia and Latin America, edible insects rich in protein, energy, minerals and vitamins have been served as food (entomophagy) for many years[1]. Recently, entomophagy has gained attention worldwide. Traditionally, India has many ethno-entomophagous groups majorly restricted to the North East, southern and central parts of the country, but the diversity of insects consumed is less in South and central India compared to the NE. The choice of insect species to be used as food by ethnic people in India is based on their availability, palatability and nutritional value as well as on local customs and traditions[2]. Coleopterans share a greater portion of edible insects; however, the small share of termites (3%) in human entomophagy is unavoidable[3]. Dewinged termite imagoes are considered delicious food in many parts of the world, which may be consumed as a main dish or side dish/snack[4]. Around 61 species of termites are considered edible and eaten in many parts of the world[5]. The imagoes that emerge during the first rainfall after the long dry period are majorly collected for edible purposes as they are rich in protein, minerals and fat[6–8]. Understanding the nutritional status of some of the commonly available termites in South India can encourage people to reconsider the practice of entomophagy in wider prospects.

Winged imagoes of major termite species were collected in the swarming period during late evening hours using sweep nets and light traps from different locations, or in the early morning below street lights, underneath grasses and soil sediments. Few imagoes were preserved in 80% ethanol for taxonomic identification of the sample and identified to species[9,10]. The collected unsexed samples were brought to the laboratory and washed thoroughly with distilled water. The washed imagoes were de-winged and oven-dried at 105°C for 30 min (ref. 11). The oven-dried termites were ground to a fine powder using a pestle and mortar, and stored at –20°C after labelling with species identity and date of collection for further analysis.

Protein composition was analysed for the imagoes of three termite species, viz. *Coptotermes heimi*, *Microtermes obesi* and *Odontotermes obesus*. While the other proximate and mineral compositions were analysed for the imagoes of *O. obesus* only. The proximate and mineral compositions of the imagoes were analysed at the Pesticide Residue and Food Quality Analysis Laboratory, University of Agricultural Sciences, Raichur (National Accreditation Board for Testing and Calibration Laboratories accredited). The moisture content of dried imagoes was determined using the drying method[12]. The crude fat was estimated by the Soxhlet extraction method, while crude protein was estimated by the semi-micro-Kjeldahl method[12]. Ash content was analysed by incinerating the sample in a muffle furnace at 550°C (ref. 12); the enzymatic gravimetric method (Prosky method) was used to analyse dietary fibre[12,13]. Analysis of minerals was performed by atomic absorption spectrometry using standards[12].

The collected samples were morphologically identified as *C. heimi*, *M. obesi* and *O. obesus*, and were used for nutritional analysis. The study documented that termites are a rich source of protein, but they vary according to the species. Among the imagoes of the three termite species, the highest crude protein of 54.95 ± 1.7% of dry matter of termites was recorded in *C. heimi*, followed by *O. obesus* with 41.68 ± 1.80% of dry matter. The least was recorded in *M. obesi* (33.21 ± 0.81% of dry matter). Similar observations are being made worldwide among different species of termites, which vary. Higher crude protein was recorded in *Macrotermes nigeriensis* (Sjostedt) (20.94% of dry matter) in Nigeria[1], *Trinervitermes germinatus* (Wasmann) (41.70% of dry matter) also in Nigeria[14], *Macrotermes bellicosus* (Smeathman) (39.74% of dry matter), *Macrotermes subhayalinus* (Pearce) (39.74% of dry matter), *Pseudocanthotermes militaris* Hagen (33.51% of dry matter) and *Pseudocanthotermes spiniger* (Sjostedt) (37.54% of dry matter) in Kenya[15], and *Odontotermes* spp. (33.67% of dry matter) collected from Arunachal Pradesh, India[8]. However, it was less compared to *Syntermes aculeosus* Emerson, which recorded a higher protein of 64% of dry matter[16] and *Reticulitermes* sp., which recorded 87.33% of dry matter[17].

During collection, *O. obesus* was observed to be one of the major termite species and was available in bulk to perform analysis. The proximate composition of dried *O. obesus* scored a higher crude fat content of 49.71 ± 2.06%, followed by protein (41.68 ± 1.80%). The total ash and crude fibre recorded were 3.98 ± 0.00 and 9.27 ± 0.07% respectively. The dried product had a moisture content of 5.66 ± 0.19%. Fat is one of the major proximate compositions of termites. The present study recorded a greater concentration of fat in *O. obesus* imagoes[1,8]. The fat content was higher than that of *Macrotermes natalensis*[18,19] and *M. bellicosus*[18,20] with 21.35–22.5 and 28.2–36.12% respectively. The fat content of *O. obesus* was comparable with termites of Kenya[15] and *M. bellicosus*[21]. Crude fibre is attributable to the amount of chitin in the termites. The quantity of crude fibre in *O. obesus* was comparable to *Odontotermes* spp. (6.30%) from Arunachal Pradesh[8], while comparably higher than that of *M. bellicosus* (2.70%), *M. natalensis* (2.20%)[18] and *M. nigeriensis* (5.71%)[1].

Table 1. Mineral composition of *Odontotermes obesus*

Proximate composite	Value (mg/kg*)
Aluminium	465.74 ± 7.56
Barium	3.50 ± 0.11
Boron	2.25 ± 0.07
Cadmium	0.11 ± 0.00
Calcium	1453.55 ± 7.86
Chromium	0.63 ± 0.02
Copper	17.84 ± 0.16
Gallium	0.49 ± 0.02
Iron	308.86 ± 10.61
Lead	0.29 ± 0.01
Lithium	0.47 ± 0.01
Magnesium	1039.64 ± 30.92
Manganese	69.34 ± 3.06
Nickel	0.44 ± 0.01
Potassium	5672.56 ± 153.40
Silver	0.04 ± 0.00
Sodium	2199.65 ± 1.98
Strontium	6.12 ± 0.17
Thallium	0.01 ± 0.00
Zinc	108.97 ± 4.22

*Mean of three samples.

Mineral composition of *O. obesus* revealed that potassium, sodium, calcium and magnesium represented the macroelements in higher quantities with 5672.56 ± 153.40, 2199.65 ± 1.98, 1453.55 ± 7.86 and 1039.64 ± 30.92 mg kg^{-1} respectively. Higher sodium, potassium, calcium and magnesium levels in *O. obesus* were within the known range of these macronutrients in other insects[8,13,15,18,22]. In microelements, aluminium, iron and zinc were represented in greater quantities with 465.74 ± 7.56, 308.86 ± 10.61 and 108.97 ± 4.22 mg kg^{-1} respectively in dried imagoes. Other micronutrients quantified were manganese (69.34 ± 3.06 mg kg^{-1}), copper (17.84 ± 0.16 mg kg^{-1}) and boron (2.25 ± 0.07 mg kg^{-1}). *O. obesus* imagoes are rich in essential micronutrients like iron and zinc[8,16]. Chromium was the most significantly represented toxic heavy metal with 0.63 ± 0.02 mg kg^{-1} of dried imagoes. Though the comparative level was high, the concentration was much less than the acceptable daily intake. Other heavy metals recorded in dried *O. obesus* imagoes were lead (0.29 ± 0.01 mg kg^{-1}) and cadmium (0.11 ± 0.00 mg kg^{-1}) (Table 1).

Termites and ants are referred to as some of the oldest edible insects[23]. They are a source of rich nutrients with a higher proportion of edible protein and fat. Eating insects is considered to be taboo in many tribal communities in India[24]. However, there is a need for large-scale studies with respect to winged imagoes, the emergence pattern of different species, proximate composition, using them for preparing various dishes, value-addition and consumption.

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