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Laetiporus sulphureus in the mid-hills of Central Nepal: ecology, ethnomycology and present status

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Abstract

Laetiporus sulphureus is a well-known edible mushroom with a high medicinal value. It is reported from different places in Nepal, particularly from mid-hill areas. However, the ecology and ethnomycology of *L. sulphureus* were poorly known in Nepal. We aimed to study the ecology, ethnomycology, and present status of *L. sulphureus* from the mid-hills of Dolakha district, central Nepal. The habitat of *L. sulphureus* in the six different sites of the study area was surveyed to find out the dominant tree species and microclimatic conditions. Additionally, a questionnaire survey was conducted to document ethnic knowledge and the status of *L. sulphureus*. We found dominance of tree species such as *Tsuga dumosa*, *Quercus semicarpifolia*, and *Rhododendron arboreum* in the habitat of *L. sulphureus*. Dead and decayed logs/trunk of these tree species were found to support *L. sulphureus* growth. Regarding microclimatic conditions, an average temperature of 20 °C, a light intensity of 1000–2000 lux, and relative humidity of 65–80% were recorded under the canopy where *L. sulphureus* was growing. Fruitbodies of *L. sulphureus* were found to be collected by local people for food and medicinal purposes. Local people were found to use dried *L. sulphureus* powder for the treatment of aliments such as diarrhea and hematochezia. The availability of *L. sulphureus* was found to be declining due to overharvesting, logging of the host tree, and the removal of coarse wood debris. Collection of *L. sulphureus* fruitbodies and logging of host tree should be regulated for its conservation in wild habitat. This study provides valuable information about the possible substrate types and environmental conditions that could be used for the successful domestication of *L. sulphureus* at the study sites and similar locations.

Keywords: *Sulphur polypore, Rato chyau, Habitat, Edible mushroom, Traditional Knowledge*

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Introduction

Laetiporus sulphureus (Bull.) Murrill is a species of polypores and is commonly known as the sulphur polypore or chicken-of-the-wood. In Nepal, it is commonly known as *Rato Chyau*, which means 'red mushroom'. *Laetiporus sulphureus* can be recognized in the field with its soft consistency, distinctive yellow to orange-red fruitbodies, and growing on shelves (Pleszczy□ska *et al.*, 2013). It has a pale yellow to white pore surface which is circular to angular in shape. Fruitbodies are up to 90 cm across and usually consist of several lobes arranged on lateral shelves and sometimes forming rosettes on dead fallen logs. The lobe size of

fruitbodies varies from 5–25 cm and 3–5 cm thick which is fan-shaped to semicircular or irregular. It has a thick flesh with soft texture when young and then becomes tougher with age. The odor and taste are not distinctive. Regarding micromorphological characteristics, it has ellipsoidal spores with a smooth surface, without hymenial cystidia, and the hyphal system is dimitic (Burdsall and Banik, 2001). *Laetiporus sulphureus* has been found to be distributed in different parts of Asia, Europe, and North America (Pleszczy□ska *et al.,* 2013). Regarding its distribution in Nepal, several studies have reported *L. sulphureus* from Sankhuwasabha district of east to Bajang district of west Nepal (Adhikari, 2014). Most of the upper temperate forests of Nepal are reported to be habitable for *L. sulphureus* (Devkota, 2008; Khadka and Aryal, 2020). *Laetiporus sulphureus* is reported to grow on dead and decaying logs/trunks of temperate hardwood tree species such as *Quercus semecarpifolia*, *Quercus glauca*, *Tectona grandis* etc. (Adhikari, 2014). *Laetiporus sulphureus* often causes heart rot in hardwood trees with thin visible areas of white mycelium, thus behaving both as a parasitic and a saprophytic form. *Laetiporus sulphureus* is widely recognized as an edible mushroom that has been used for food and medicinal purposes for centuries, particularly in China, Japan, and Korea. Fruitbodies of *L. sulphureus* have been reported to contain high protein, fiber, carbohydrates, and a low amount of fat (Luangharn *et al.,* 2014). Studies have also reported various bioactive compounds in *L. sulphureus* such as alkali-soluble polysaccharides that are known for antimicrobial, antioxidant, anti-inflammatory and immunomodulating properties (Olennikov *et al.*, 2009; Elkhateeb *et al.*, 2021; Ullah *et al*., 2022).

Although *L. sulphureus* has remarkable nutraceutical values and is routinely collected by rural communities in the growing seasons in different places of Nepal, studies regarding ecology, ethnomycology, and the status of *L. sulphureus* in Nepal are not yet available. There are no specific studies regarding habitat preference of *L. sulphureus*, tree species composition in its habitat, host tree species, optimal environmental conditions that support its growth. There is no data regarding medicinal use (for which disease/aliment, mode of use, dose of use) of *L. sulphureus*. Therefore, to partly fulfill this knowledge gap, this study aimed to assess ecology (dominant tree species in the habitat of *L. sulphureus*, host tree species, microclimatic conditions) and ethnomycological studies including present status (retailing, threats, etc.) in the mid-hills of central Nepal.

Materials and Methods

Study area

The study sites are located in different places in the Dolakha district, Bagmati province, central Nepal (Figure 1, Table 1). The mean annual temperature is 19 °C (maximum) and 8 °C (minimum) while the mean annual precipitation is 2043.5 mm (DDC, 2015). The study sites are composed of vegetation that are typical for lower temperate region with tree species such as *Tsuga dumosa*, *Quercus semicarpifolia*, *Rhododendron arboreum*, *Symplocos* spp. etc. and shrub species comprises *Sarcococca* spp., *Gaultheria fragrantissima*, *Butea* spp., , *Eurya accuminata*, *Thalictrum* spp.,

Table 1: Study sites with their geographical position and location.

SN	Study site	Geographical position	Altitude (m)	Location
1	Lakuridada	27°43’02” N 85°58’36” E	2863	Bhimeshwor Municipality
2	Shailung	27°37’22” N 85°57’15” E	2562	Sailung Rural Municipality
3	Kalinchowk	27°48’49” N 86°03’00” E	2758	Kalinchowk Rural Municipality

4	Boch	27°42'29" N 85°58'17" E	2591	Bhimeshwor Municipality
5	Khawa	27°39'25" N 86°12'02" E	2868	Jiri Municipality
6	Bigu	27°48'43" N 86°09'31" E	2814	Bigu Rural Municipality

According to the Nepal census 2021, The study sites were dominated by the ethnic communities (Tamang, Thami, Newar, Sherpa, Kami, Jirel etc) comprising 83.02%, 56.38%, 69.33%, 65.98% and 61.27% in Bigu rural municipality, Kalinchowk rural municipality, Jiri municipality, Sailung rural municipality and Bhimeshwor municipality respectively (NPHC, 2021).

Ecological study

The ecological study of *L. sulphureus* was carried out in order to know the weather and seasonality favorable for its growth, dominant tree species that occur in its habitat and the substrate that supports its growth. Growing season, altitude range including microclimatic conditions (light intensity, temperature, and relative humidity) were recorded (at 5 locations/sites) under tree canopy where the *L. sulphureus* were fruiting. Starting in July 2022, the measurements were taken for five consecutive days at three different times in the morning, afternoon, and evening from five different places within each site. The second measurement was taken in August 2022 and the third in September of 2022. Temperature and humidity were measured with digital Temperature + Humidity Meter (model no: HTC-1, Sigma instruments) and light intensity with Luxmeter (model no: ST-UT381). The tree species types were recorded on a study site. The herbarium specimens of the *L. sulphureus* was prepared and identified based on standard literature (Adhikari, 2014; Pacioni and Lincoff, 1981) and deposited in the ASCOL Herbarium. Meanwhile, the substrates (dead logs) were also identified where the primordia of *L. sulphureus* were seen.

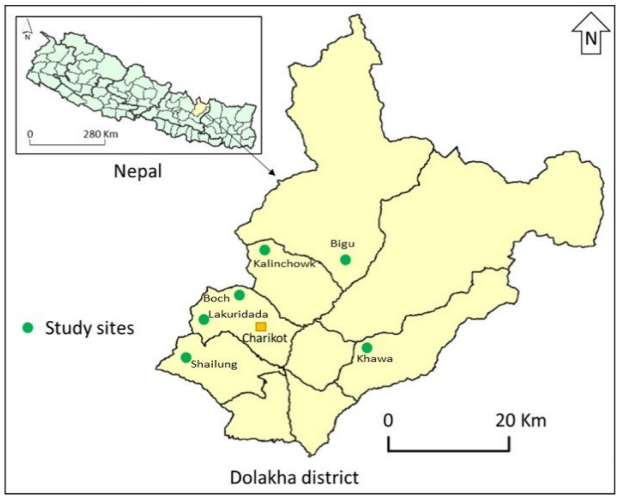

Figure 1: Location map of the study area

Ethnomycological study and present status

The ethnomycological study was carried out in order to know the use of *L. sulphureus* in different preparations. Meantime, status such as harvest, retailing, and conservation status was studied. Twenty respondents were selected based on their proximity to the forest. A semi-structured questionnaire was used for this purpose (Yilmaz and Zencirci, 2016). The questionnaire was constructed to obtain vital information including substrates of mushrooms and fruiting periods, uses of mushrooms (food or medicine), methods of preparation, harvest, method of preservation, mode of use, retailing and present status of *L. sulphureus*.

Results

Ecology of *Laetiporus sulphureus*

Laetiporus sulphureus was found to grow in the wet season, commonly from July to October. Occasionally, fruitbodies were reported to be found

as early as May after the first shower of rain. The average values of temperature, light intensity, and relative humidity in three different months July, August and September are shown in Table 2.

Table 2: Temperature, light intensity, and relative humidity during July, August, and September 2017 (N=5).

Month	Average temperature (ºC)	Average Light intensity (Lux) below the canopy	Average Relative humidity (%)
July	20	1200	86
August	21	1500	75
September	20	1800	65

Laetiporus sulphureus was found to grow mainly in temperate region of the study area i.e., from 2500-3500 m asl. In lower altitude, the vegetation was dominated by tree species such as *Quercus lanata*, *Castanopsis indica*, *Castanopsis hystrix,* and *Symplocos ramosissima* (Table 2). Likewise, vegetation in higher altitude was dominated by *Tsuga dumosa*. Additionally, the lower vegetation is composed of shrub species such as *Sarcococca* spp., *Eurya acuminata*, *Gaultheria fragrantissima*, *Viburnum* sp., *Berberis aristata*, *B. asiatica*, *Pyracantha crenulata,* etc.

Table 3: Some dominant tree species in the forest of study area where *L. sulphureus* is growing.

SN	Scientific Name	Family	Local name
1	*Tsuga dumosa* Eichl.	Pinaceae	Thingre salla
2	*Pinus wallichiana* A.B.Jacks.	Pinaceae	Gobre salla
3	*Lyonia ovalifolia* (Wall.) Drude.	Ericaceae	Angeri
4	*Symplocos ramosissima* Wall. ex G. Don.	Symplocaceae	Kharane
5	*Symplocos pyrifolia* Wall. & G. Don	Symplocaceae	Kholme
6	*Quercus semecarpifolia* Sm.	Fagaceae	Khasru
7	*Quercus lanata* Sm.	Fagaceae	Bhanj
8	*Lindera nacusua* (D. Don) Merr.	Lauraceae	Paheli
9	*Castanopsis hystrix* A.DC.	Fagaceae	Katus
10	*Castanopsis indica* A.DC.	Fagaceae	Dhale Katus
11	*Lithocarpus* sp. Blume	Fagaceae	-
12	*Daphniphyllum himalense* (Benth.) Mull. Arg.	Daphniphyllaceae	Chandan
13	*Rhododendron arboreum* Sm.	Ericaceae	Laliguras

Dead and decaying logs or trunks of *Tsuga dumosa, Pinus wallichiana, Lyonia ovalifolia,* and *Quercus* spp. were found to support the growth of *L. sulphureus.* The first flush of *L. sulphureus* was found mainly in dead logs from *Tsuga dumosa* (Figure 2), and then the last flush was found mainly in dead logs from *Rhododendron arboreum* (in October). But they sprout in the logs of other tree species, such as *Lyonia ovalifolia*, *Quercus semicarpifolia* and *Lithocarpus elegans,* during the month of September. *Quercus semicarpifolia* was found to be the common living host of *L. sulphureus* (Figure 2).

Ethnomycology and Present status of *L. sulphureus*

A total of 20 respondents were interviewed that include key informants from different ethnic groups such as Tamang, Thami, Sherpa, Newar, and Kami.

Figure 2: A, Primorida of *L. sulphureus*; B, young fruit bodies: C and D, Mature fruit bodies on the dead log of *Tsuga dumosa* and *Quercus semecarpifolia* trunk.

Figure 3: A, Collector collecting mushroom (*Laetiporus sulphureus*); B, Collected mature mushroom; C, Preparing collected mushroom to dry for long term preservation, and D, Making fresh mushroom ready for cooking.

In the Dolakha district, it was found that the mushroom collection was dominated by men (65%, N=13) than by women (35%, N=7). Most of them are literate farmers aged 30-50 years (Table 3). Usually, they were found collecting mushrooms during their regular activities in the forest.

Table 4: Demographic characteristics of the key informants.

Category	Demographic variables	Total	Percentage (%)
Gender	Male	13	65
	Female	7	35
Age group (years)	< 30	3	15
	30-50	10	50
	> 50	7	35
Occupation	Farmer	12	60
	Household	4	20
	Job	2	10
	Business	1	5
	Student	1	5
Education	Literate	16	80
	Illiterate	4	20

Respondents have reported that fruitbodies of *L. sulphureus* were usually available in a bulk amount in the forests during the growing seasons. People who collected the fruitbodies of *L. sulphureus* used to remember that place and then visit the same place year after for the next collection. Usually, only the harvesters who know the place well were able to find the quality fruitbodies of *L. sulphureus*. The harvesters were found to prefer to collect *L. sulphureus* fruitbodies in the right stage, i.e., neither in young nor old fruitbodies, because young and old fruitbodies are reported to have less organoleptic properties (Figure 3). The collected fruitbodies were thoroughly cleaned and cooked as normal vegetables. They did not report special preparation such as boiling in black pepper water before cooking. Regarding medicinal values, dried *L. sulphureus* powder was used to cure aliments such as diarrhoea, hematochezia, stomachache (intestinal cramps), weak immune system, fatigue, common cold, high blood sugar, high blood pressure, etc. (Table 4). Mostly, they dissolve *L. sulphureus* powder in hot water or milk at various concentrations and use it.

Table 4: Traditional uses of the *L. sulphureus* for different nutraceutical and pharmaceutical purposes.

Disease/ailments	Mode of use	Amount	Dose
Diarrhea	Dried powder with hot water	1 TS	2 times/day
Hematochezia (blood in stool)	Dried powder/pieces with hot water (like Tea)	1 TS	3-4 times/day
Stomachache (Intestinal cramps)	Dried powder with hot water	1 TS	3 times/day
Weak Immune system	Dried powder with hot milk; as curry and pickle	n/a	n/a
Weakness and Fatigue	Dried powder with hot milk/water	1-2 TS	Not regular
Common cold	Dried powder/pieces with hot water (like Tea)	1 TS	4-5 times/day
High blood sugar	Dried powder/pieces with hot water (like Tea)	1 TS	4-5 times/day
High blood Pressure	Dried powder/pieces with hot water (like Tea)	1 TS	4-5 times/day

Note: n/a – no clear dose, TS – Tablespoon

Locals who have been collecting *L. sulphureus* since childhood observe that the amount of collection is very little these days. Some 30 years earlier, they reported that *L. sulphureus* was found to be growing more frequently around the altitude of 2500 m in dead logs of *Quercus* spp., but these days they are not. The harvesters collected *L. sulphureus* not only for their own consumption but also for sale in the local market. Nowadays, fruitbodies of *L. sulphureus* were also found to have a high demand in the local town (Charikot) and are traded in vegetable markets with a relatively high price (1000-1200 rupees/Kg) compared to other commercial mushrooms. Most locals prefer to buy and eat *L. sulphureus* than other domestic mushrooms due to its better organoleptic properties. Consequently, many professional harvesters were collecting *L. sulphureus* in the sprouting season of April and mid-September. According to the respondents, the major threats to *L. sulphureus* include logging of host trees, extraction of dead and decaying logs of host tree, and overharvesting of *L. sulphureus* fruitbodies not only for their own consumption but also for sale in local markets. However, no effort was made to address these threats to ensure the conservation and sustainable harvest of *L. sulphureus*.

Discussion

Based on available literature such as Devkota (2008), and Khadka and Aryal (2020), this study has also reported that altitude range of 2500–3000 m asl. as favorable for *L. sulphureus*. But interestingly, Aryal and Budhathoki (2012), and Aryal *et al.* (2014) recorded *L. sulphureus* from the tropical region (Rupandehi district) of central Nepal in *Tectona grandis*. The distribution of *L. sulphureus* in such two different bioclimatic zones could be due to the microclimate created by the canopy of the tree as described by Kewessa *et al.* (2022). Remarkably, we found fruiting of *L. sulphureus* twice a year, first in April to May when there is considerable moisture in the forests and then from July to September. Similar to our observation European studies have also reported fruiting of *L. sulphureus* twice a year (Gaper, 1994).

Like other fleshy mushrooms, it was found that *L. sulphureus* prefer warm and humid climates and shady places with low light intensity level (Table 2). This mushroom fruits twice a year which may be due to the period of warm and humid

condition followed by exposure to bright sunlight favor primordia formation (Pleszczy□ska *et al.,* 2013). This information will be vital for the domestication of *L. sulphureus*. Regarding host tree species, it was found that there was no substrate specificity of *L. sulphureus* and was found to colonize both softwood tree species such as *Pinus wallichiana* and hardwood tree species such as *Quercus* spp. and *Rhododendron arboreum*. Interestingly, although *L. sulphureus* prefer dead or decayed logs of host tree species, we found fruitbodies of *L. sulphureus* in living tree of *Quercus semicarpifolia* which was also reported by Adhikari (1988), Kharel and Rajbhandary (2005), Khadka and Aryal (2020).

Traditional utilization of *L. sulphureus* for medicinal and food purpose has been reported from different parts of Nepal such as in the Baglung, Myagdi, and Kaski districts (Mishra and Mishra 2013), Kathmandu (Adhikari, 1988; Pandey e*t al.*, 2006; Mishra and Mishra, 2013; Khadka and Aryal, 2020), Dolpa (Devkota 2008), Lamjung, Mustang (Christensen *et al.*, 2008), Kavrepalanchok, Dhankuta, Sunsari, Rasuwa (Pandey *et al.*, 2006) etc. Studies have shown that *L. sulphureus* have nutritional values of 72.64g carbohydrates, 15.97g proteins, 2.35g fats, 9.03g ash and 375.62 Kcal energy per hundred gram of dry weight (Petrovi□ *et al.*, 2014). As *L. sulphureus* is usually found in a bulk amount, the collected mushrooms are also stored in their dry form (sun-dried) for later use. Especially, dried *L. sulphureus* powder is consumed for medicinal purposes used to cure some alimentary diseases like diarrhea, and hematochezia (blood in stool) and other aliments (Table 2). Similar to our observation, Molina *et al.* (2001), Adhikari *et al.* (2005), Ullah *et al.* (2022) have also reported the several pharmaceutical and nutraceutical properties of *L. sulphureus.* Studies have found *L. sulphureus* as a rich source of chemical compounds, including as polysaccharides, phenolics, and triterpenes, which have a variety of biological actions, including anti-inflammatory, anti-microbial, anticancer, antioxidant, anti-hyperglycemic, anti-tumor, and immunomodulatory effects (Khatua *et al.*, 2017).

As *L. sulphureus* have both high organoleptic properties and medicinal values, high prices in local market that have posed remarkable threats. Removal of coarse wood debris for firewood and timber (logging of host trees like *Tsuga, Rhododendron* and *Quercus*) reduce the available substrate for the mushroom which affect the fungal community in the forest ecosystem (Tamao *et al*., 2020; Langer *et al*., 2021). Beside this unregulated harvesting or overharvesting and deforestation were also the major threats for *L. sulphureus* which were also reported by Devkota (2008) for the wild mushroom. For the sustainable harvesting of *L. sulphureus*, it is crucial to record and monitor, as well as actual and potential collection sites must be plotted. Therefore, domestication of *L. sulphureus* is essential for sustainable harvest.

Conclusion

This study has identified that fruitbodies of *L. sulphureus* can be found in two different seasons in midhills of the Dolakha district, first after pre-monsoon rain and second during monsoon but in different host tree species. *Laetiporus sulphureus* mostly prefer dead and decaying logs or trunks of temperate hardwood tree species such as *Tsuga dumosa, Lyonia ovalifolia, Rhododendron arboreum, Quercus semicarpifolia* etc. During growing seasons, the average air temperature was approximately 20±1°C, light intensity of 1000 lux to 2000 lux and relative humidity of 65 to 80% under the canopy. Local people used to collect *L. sulphureus* neither in young stage nor in old stage and use it as food and medicine. Local people have identified removal of dead woods, overharvesting, and deforestation are major threats for *L. sulphureus*. Consequently, monitoring collection and domestication of this species is crucial for the conservation and sustainable harvest.

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