

PRELIMINARY RECORD OF ECTOMYCORRHIZAL FUNGI ON TWO CALIFORNIA CHANNEL ISLANDS

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Abstract—Santa Cruz and Santa Rosa Islands of the northern Channel Islands contain unique floral communities comprised of many California and island endemics. These communities, dominated by *Pinus*, *Quercus*, and *Arctostaphylos*, are obligately ectomycorrhizal with certain groups of fungi. In this symbiosis, fungi are intimately associated with plant root cells. Photosynthetic carbon is transferred to fungi and plants receive mineral nutrients acquired by the fungi from soil. It is likely that a diverse assemblage of ectomycorrhizal fungi associate with these plants, but no published list or publicly available vouchers exist for the fungi. Our primary work on the islands involved collecting samples of *Rhizopogon* species from pine communities for an ongoing population genetics study, but we also collected, identified, and vouchered other fleshy fungi from multiple locations. We are now identifying these latter collections and depositing them in the University Herbarium at the University of California, Berkeley. Here we report our initial findings, representing the first published list of fleshy fungi on the islands. We found a high diversity of species, including representatives from the three major fungal phyla that participate in ectomycorrhizal symbioses. We found both epigeous (aboveground) and hypogeous (belowground) species, as well as species previously undescribed.

Keywords: Ascomycetes, Basidiomycetes, conservation, diversity

INTRODUCTION

The vascular plant flora of California, including the inhabitants of the Channel Islands, is now reasonably well documented, and modern technical keys are available (Hickman 1993, Junak et al. 1995). In contrast, no mycota has ever been attempted for the state, even for the larger fleshy fungi, and modern technical keys are available only for select groups of fungi (Thiers 1975, Thiers 1982, Largent 1985, Kerrigan 1986, Methven 1997, Shanks 1997, Thiers 1997). The differences in the states of knowledge of plants and fungi are probably due in part to the small number of professional mycologists and in part to the unpredictable timing of fungal fruiting and the short duration of individual fruiting bodies.

Knowledge of the Channel Islands mycota until now consisted of a single species list for Santa Cruz compiled by Dr. John Menge at the University of California at Riverside, plus a small amount of additional collecting done by others. Dr.

Menge's list was the result of two class trips in May 1981 and March 1982 to Santa Cruz (J. Menge pers. comm.). There are 97 fungal species on this list of which 43 are saprotrophic fungi or fungal parasites. These specimens and the species list were placed in the Santa Cruz Island Nature Reserve Herbarium, but unfortunately most of the specimens have been eaten by insects or covered by mold (L. Grubisha pers. observ.). Dr. Robert Cummings at Santa Barbara City College made collections of 50 fungal species from three trips to Santa Cruz in January 1984, and February 1985 and 1999 (R. Cummings pers. comm.). In addition, the late Prof. Harry Thiers made a small number of collecting trips to Santa Cruz and deposited specimens in the Thiers Herbarium at San Francisco State University (H. Thiers pers. comm. to TDB 1988).

We report here the initial results of two collecting trips to Santa Cruz (March 2001 and January 2002) and two to Santa Rosa (March 2001, March 2002). We collected a few fungal specimens

on two other trips to Santa Cruz in July 2000 and April 2001, however these trips were not designated collecting trips and thus we did not spend much time collecting fungi. This report is preliminary in several ways. First, it is not a comprehensive list because of the short seasonal windows in which we sampled. Second, the identifications remain preliminary in many groups. Third, it is floristically biased by plant communities because the main focus of our trips was to collect specimens of two particular fungi, *Rhizopogon occidentalis* and *R. vulgaris*, for an ongoing population genetics study being conducted by the senior author. These particular fungi are ectomycorrhizal associates with pine, so we sampled the native pine stands extensively. However, we collected other fleshy fungi both within the pine stands and in various other plant communities. Fourth, our collecting was biased towards ectomycorrhizal fungi. Nevertheless, this list represents the most comprehensive list to date.

METHODS

Study area

Santa Cruz and Santa Rosa are two of the four islands that make up the northern Channel Islands. Fluctuating sea levels during the last glaciation (>13,000 years ago) led to periods in which these islands were a contiguous landmass forming one large island called Santarosae (Vedder and Howell 1980). There is no evidence that a land bridge connected any of these islands to the mainland, although during the Pleistocene the oceanic levels were much lower and only a 7 km distance separated the eastern end of Santarosae to the mainland at Ventura, California, compared to a separation of 20 km today (Junger and Johnson 1980).

The islands differ both by size and distance from the mainland. Santa Cruz is larger than Santa Rosa (249 km² and 217 km², respectively), and lies 30 km southeast of Ventura, while Santa Rosa is 9 km west of Santa Cruz and 44 km from the mainland (Schoenherr et al. 1999). The highest point on Santa Cruz is 753 m, while on Santa Rosa the highest point is 484 m. Both have a Mediterranean climate characterized by cool, wet winters and warm, dry summers.

Sampling

Native pine areas on both islands were intensively searched for *Rhizopogon occidentalis* and *R. vulgaris*. On Santa Cruz four such areas were dominated primarily by *Pinus muricata* with a mixed community including *Quercus* spp., *Arctostaphylos* spp., and *Ceanothus* spp., whereas on Santa Rosa there were two locations with pines, one small stand of *Pinus muricata* and another of *Pinus torreyana* (Table 1). Distribution of the two pine species does not appear to overlap. On both islands some forested areas without pines were also searched for fungal fruiting bodies, but the focus was on ectomycorrhizal fungi (Table 1). Steep slopes, elevation, access to roads, and shrub understory density hindered collection in some areas, especially on Santa Cruz. For these reasons most of the accessible area within habitats was searched but an area of uniform size was not covered at each location.

Fungal collections

Specimens were put in waxed paper sandwich bags. On Santa Cruz they were kept in a cooler with freezer packs while in the field and then stored in a cold room (4°C) at the field station until examination. Upon return to the field station at Santa Rosa, collections were kept in a cooler with freezer packs. Field identifications were based on gross morphological characters and use of references (Arora 1986) that were later confirmed by examination of microscopic characters. In some cases further identification was accomplished by comparison of DNA sequences (e.g., *Rhizopogon*, *Suillus quiescens* nom. prov.). Notes and digital images were taken on fresh specimens that were then dried on a food dehydrator with forced air at 35°C (95°F). Hypogeous species were examined microscopically and identified by keys and either published descriptions (e.g., Smith and Zeller 1966) or those developed from long-term study of the genera involved. Identification of epigeous genera was confirmed with microscopic examination and the use of taxonomic keys, including those developed for California fungi when available (e.g., Thiers 1975, Thiers 1982, Methven 1997, Shanks 1997, Thiers 1997). Collections will be accessioned into the University Herbarium, University of California at Berkeley (UC).

Table 1. Location, Global Positioning System coordinates, primary vegetation type of sites, and date sampled on Santa Cruz and Santa Rosa Islands.

Location	GPS coordinates	Primary vegetation type	Date sampled
Santa Cruz Island			
Ridge Road	34 × 00N, 119 × 47W – 34 × 01N, 199 × 49W	<i>Pinus muricata</i> , <i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i>	July 2000, March and April 2001, January 2002
Island Ironwood grove	34 × 00N, 119 × 45W	<i>Lyonothamnus floribundus</i> ssp. <i>Asplenifloius</i> , <i>Quercus</i> , <i>Arctostaphylos</i>	March and April 2001, January 2002
Sauces Canyon	34 × 00N, 199 × 48W – 33 × 59N, 199 × 49W	<i>P. muricata</i> , <i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i>	July 2000, March and April 2001, January 2002
UC Nature Reserve Station	33 × 59N, 119 × 43W	<i>Quercus</i> , <i>Eucalyptus</i>	July 2000, March and April 2001, January 2002
Pelican Bay Trail	34 × 01N, 119 × 41W – 34 × 01N, 119 × 42W	<i>P. muricata</i> , <i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i>	July 2000, March and April 2001, January 2002
East End Road	33 × 59N, 119 × 38W – 34 × 00N, 119 × 37W	<i>P. muricata</i> , <i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i>	July 2000, March and April 2001, January 2002
China pines	34 × 01N, 119 × 36W	<i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i> , <i>P. muricata</i>	July 2000, March and April 2001, January 2002
Los Piños del Sur	33 × 59N, 119 × 36W	<i>P. muricata</i> , <i>Quercus</i> , <i>Arctostaphylos</i> , <i>Ceanothus</i>	January 2002
Santa Rosa Island			
Torrey pine grove	33 × 59N, 120 × 01W	<i>Pinus torreyana</i> ssp. <i>insularis</i>	March 2001 and 2002
Bishop pine stand	33 × 58N, 120 × 04W	<i>P. muricata</i> , <i>Adenostoma fasciculatum</i>	March 2001 and 2002
Ironwood Canyon I	33 × 59N, 120 × 02W	<i>L. floribundus</i> ssp. <i>asplenifloius</i> , <i>Quercus</i> , <i>Arctostaphylos</i>	March 2001 and 2002
Ironwood Canyon II	33 × 58N, 120 × 02W	<i>L. floribundus</i> ssp. <i>asplenifloius</i> , <i>Quercus</i> , <i>Arctostaphylos</i>	March 2001
Cherry Canyon	33 × 59N, 120 × 04W	<i>Quercus</i> , <i>Arctostaphylos</i>	March 2001 and 2002
Lobo Canyon	34 × 01N, 120 × 05W	<i>Quercus</i> , <i>Arctostaphylos</i>	March 2001 and 2002
South Point Canyon	Not recorded	<i>Quercus</i> , <i>Arctostaphylos</i> , <i>L.</i> <i>floribundus</i> ssp. <i>asplenifloius</i>	March 2001

RESULTS

All three fungal phyla that have derived the ectomycorrhizal symbiosis are represented on both Santa Cruz and Santa Rosa. Basidiomycetes comprised 87.3% of the species collected, 12% were Ascomycetes, and 0.7% were Zygomycetes. In the Zygomycetes, the only genus known to be ectomycorrhizal is *Endogone* and *Endogone lactiflua* was collected on both islands.

We have identified 151 fungal species or species groups (Appendix 1). Excluded from this total are the 39 specimens that we identified as *Cortinarius* sp. 1–3, *Dermocybe* sp. 1–7, *Entoloma* sp. 1–5, *Inocybe* sp. 1–7, and *Russula* sp. 1–17 because at present species identification is uncertain. We recognize that this is a preliminary

record and further investigation will produce some species name changes, particularly in difficult genera such as *Cortinarius*, *Dermocybe*, *Inocybe*, and *Russula*; however, we suggest that for now preliminary names will function well to indicate diversity, and vouchers can be checked in the future by other researchers. Currently, we are sequencing the nuclear ribosomal internal transcribed spacer region (ITS) from *Balsamia*, *Casia*, *Inocybe*, *Hydnoplicata*, *Laccaria*, *Lactarius*, *Melanogaster*, and *Russula* (including *Macowanites*), and combining these data with microscopic analysis. Because these studies are ongoing, results will be published elsewhere. Of the 151 identified species, 131 are epigeous and 20 are hypogeous. Twenty-one epigeous species were common to both islands, 92 were found only on Santa Cruz, and 18 only on

Santa Rosa. Of the 20 hypogeous species, six are common to both islands, 12 were collected only on Santa Cruz while one was only collected on Santa Rosa. From the 151 species total, 129 are putative ectomycorrhizal species (109 epigeous and 20 hypogeous). Species that occurred on both islands, especially those that were collected in March 2001 when the islands were sampled one after the other, are identified in Appendix 1. On Santa Cruz, 92 species were collected in January 2002 and 85 in March 2001, nine in April 2001, and two in July 2000. On Santa Rosa, 53 species were collected in March 2001, but only two in March 2002.

Several species are undescribed and at least one appears to be rare. One undescribed species of *Suillus* is common on Santa Cruz. It is similar to *S. brevipes*, but is much lighter in color and has a distinctive ITS sequence (T. Bruns and L. Grubisha unpubl. data). Two new *Russula* (*Macowanites*) species are listed by provisional names here, *Russula insularis* and *Russula santarosana* (Appendix 1). The two species are found on both islands although *R. santarosana* was only collected once on each island, whereas a total of 14 collections were made of *R. insularis* on Santa Cruz but only one collection was made on Santa Rosa. We have collected a putative new species of *Russula* that is macroscopically similar to *Russula vesicatoria* (S. Miller pers comm.). *Russula vesicatoria* is associated with conifers and is common in the eastern United States (S. Miller pers comm.). The specimen collected on Santa Cruz was found fruiting in a stand of Island Ironwood (*Lyonothamnus floribundus* ssp. *aspleniifolius*), a species that is only found on three of the Channel Islands (Junak et al. 1995). Island ironwood is a member of the Rosaceae, a family known to be ectomycorrhizal (Trappe 1987, Smith and Read 1997). Another *Russula* collection found with *Pinus torreyana* on Santa Rosa is in the *R.* subgenus *Compactae*, a group that stains red and/or black. This specimen, though, does not fit well with any description in Thiers' (1997) taxonomic account of *Russula* species found in California. *Thelephora scissilis* Burt is a very distinctive species because of its combination of small stature, clavarioid form and lobate-spiny spores, and it appears to be a rare species by scarcity of records of it in the literature. We made one collection of this species on Santa Cruz.

Several non-mycorrhizal fungal species were collected that were fruiting with the ectomycorrhizal fungi. These included fungal parasites and saprotrophic fungi (Appendix 1). An *Armillaria* species, which causes root rot, was collected from a *Eucalyptus* tree at the UC Natural Reserve Station. Three species are fungal parasites of other fungi. *Microthecium geopora* parasitized two collections of *Geopora cooperi*. *Sepedonium* is a fungal parasite of the Boletales. *Sepedonium chrysospermum* parasitized two *Boletus* specimens, and a *Sepedonium* sp. parasitized two *Melanogaster* collections.

DISCUSSION

We have initiated a record of ectomycorrhizal fungi that occur on two of the California Channel Islands. High species diversity was found on these islands, including representatives from the three fungal phyla known to form ectomycorrhizae and many genera that have been recorded in other western U.S. fungal surveys (North et al. 1997, O'Dell et al. 1999, Smith et al. 2002). The larger number of fungal species found on Santa Cruz compared to Santa Rosa parallels the pattern seen in floristic surveys. According to Schoenherr et al. (1999) Santa Cruz has 480 native plants, including eight endemic species, while Santa Rosa has 387 species and four endemics. Floristic surveys on Santa Cruz date back to 1874 (Junak et al. 1995) but only to 1981 for fungal surveys. Comparisons of our collections between islands are biased for Santa Cruz by several factors, including greater sampling intensity and sampling during more seasons. However, we did find differences in fungal fruiting between the two islands when they were sampled consecutively in March 2001 when we collected 85 species on Santa Cruz but only 53 on Santa Rosa (Appendix 1). The fruiting season appeared to begin earlier on Santa Rosa than Santa Cruz, because many of the Santa Rosa fruiting bodies were old and less numerous. In addition, our spore bank sampling of *Rhizopogon* species should not be biased by season (Kjøller and Bruns 2003), yet *R. vulgaris*, abundant on Santa Cruz in bioassays, was only found in 6% of pine seedling bioassays for Santa Rosa (Grubisha and Bruns unpubl. data).

Variation in precipitation between islands and seasons may impact the level of fungal fruiting. During the years we sampled, 2001 and 2002, Santa Cruz had slightly more rainfall than Santa Rosa, but both islands had significantly more precipitation in 2001 than 2002 (Western Regional Climate Center http://www.wrcc.dri.edu/channel_isl/index.html). On Santa Cruz the precipitation for December 2000–April 2001 was 244 mm, excluding January when data were not recorded. There were 267 mm of precipitation on Santa Rosa for the same time period, including 66 mm in January 2001. The amount of precipitation dramatically decreased during the next season. Only 69 mm of precipitation was recorded for Santa Cruz and 56 mm for Santa Rosa during December 2001–April 2002 and for both islands 70% of the total precipitation recorded during these months came in December 2001. The dramatic decrease in precipitation in 2002 resulted in a significant decline in fungal fruiting in March 2002. We only collected two species on Santa Rosa in March 2002 compared to 53 in 2001.

There were few commonalities between the species lists we compiled compared to those recorded by previous researchers. The greatest overlap in species collected were the 25 species from our study and J. Menge's class collections in May 1981 and March 1982 (Appendix 1). Many of the collections from Menge, Cummings, and Thiers were fungal parasites or saprotrophs, which were not the main focus of our collecting efforts. Some overlap may go unrecorded due to changes in identification techniques and literature during the past 22 years. For instance, *Casia flexiascus* resembles *Tuber* macroscopically, but was not described until 1989 (Trappe 1989). It is possible that our *Casia flexiascus* is their *Tuber* sp. In any case, the low level of duplication suggests that the mycota remains grossly under sampled.

We have continued the work begun by Drs. John Menge, Robert Cummings, and Harry Thiers recording fungal species diversity on Santa Cruz, and we have the first records of many fungi from Santa Rosa. Our work demonstrates that a wide variety of ectomycorrhizal fungal species is found in these unique insular communities. This work needs to be continued in order to catalogue rare and new species as well as Channel Islands and California endemics.

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Appendix 1. Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
Epigeous taxa				
<i>Agaricus californicus</i> ^a	LG415	Santa Cruz	March	M
<i>Agaricus xanthodermus</i> ^a	LG487, LG623, LG624, LG1020	Both	January, March ^c	M
<i>Amanita alba</i>	LG491	Santa Cruz	March	
<i>Amanita calyptratoides</i>	LG1063, LG1064	Santa Cruz	January	
<i>Amanita</i> cf. <i>cokeri</i>	LG457, LG463, LG521, LG522, LG545, LG742, LG767, LG1121	Both	January, March ^c	
<i>Amanita constricta</i>	LG433, LG450, LG575	Both	March ^c	
<i>Amanita gemmata</i>	LG878, LG1049	Santa Cruz	January	C, M
<i>Amanita</i> cf. <i>gemma</i>	LG366, LG380, LG550, LG558, LG570, LG584, LG594, LG676, LG1060	Both	January, March ^c , April	
<i>Amanita gemmata</i> var. <i>exannulata</i>	LG380, LG570	Both	March ^c	
<i>Amanita magniverrucata</i> group	LG668, LG597, TDB2948	Both	March ^c , April, July	T
<i>Amanita muscaria</i>	LG382, LG882	Santa Cruz	January, March	
<i>Amanita</i> cf. <i>muscaria</i> group	LG458, LG881, LG1066	Santa Cruz	January, March	
<i>Amanita</i> cf. <i>muscaria</i> var. <i>formosa</i>	LG862, LG864, LG1024	Santa Cruz	January	
<i>Amanita novinupta</i>	LG413, LG499, LG548, LG583, LG607, LG879, LG1061	Both	January, March ^c	C, M
<i>Amanita ocreata</i>	LG405, LG414, LG437, LG493, LG549, LG556, LG 606, LG610	Both	March ^c	C, M
<i>Amanita</i> cf. <i>ocreata</i>	LG547	Santa Rosa	March	
<i>Amanita pantherina</i>	LG307, LG311, LG430, LG454, LG536, LG582, LG586, LG658a	Both	March ^c , April	M
<i>Amanita</i> sp.1	LG348	Santa Cruz	March	
<i>Amanita</i> sp.2	LG1065	Santa Cruz	January	
<i>Amanita</i> sp.3	LG588	Santa Rosa	March	
<i>Amanita</i> sp.4	LG676	Santa Cruz	April	
<i>Amanita vaginata</i>	LG399, LG400, LG856	Santa Cruz	January, March	M
<i>Amanita velosa</i>	LG306, LG416, LG540, LG543, LG652	Both	March ^c , April	M, T
<i>Armillaria</i> sp. ^a	LG1018	Santa Cruz	January	
<i>Astraeus</i> sp.1	LG429	Santa Cruz	March	
<i>Astraeus</i> sp.2	LG650	Santa Cruz	April	
<i>Astraeus hygrometricus</i>	LG320	Santa Cruz	March	C, M

Appendix 1. (Continued) Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Bolbitius</i> sp. ^a	LG1378	Santa Cruz	January	
<i>Boletus amygdalinus</i>	LG426, LG465, LG1015, LG1125	Santa Cruz	January, March	
<i>Boletus barrowsii</i>	LG572, LG1016	Both	January, March	
<i>Boletus</i> cf. <i>chryseron</i>	LG408, LG503, LG535, LG552, LG612	Both	March ^c	
<i>Boletus dryophilus</i>	LG534, LG707, LG719, LG1129	Both	January, March	C, M
<i>Boletus flaviporus</i>	LG364, LG492, LG1019	Santa Cruz	January, March	M
<i>Boletus</i> cf. <i>pulverulentus</i>	LG865	Santa Cruz	January	
<i>Boletus regius</i>	LG601	Santa Rosa	March	
<i>Boletus</i> sect. <i>Boletus</i> subsect. <i>Lurdi</i>	LG476	Santa Cruz	March	
<i>Boletus</i> sp.1	LG535	Santa Rosa	March	
<i>Boletus</i> sp.2	LG525	Santa Rosa	March	
<i>Boletus subtomentosus</i>	LG829	Santa Cruz	January	C, M
<i>Boletus truncatus</i>	LG580	Santa Rosa	March	
<i>Boletus zelleri</i>	LG566, LG600	Santa Rosa	March	
<i>Calvatia</i> cf. <i>hesperia</i> ^a	LG1057	Santa Cruz	January	
<i>Cantharellus californicus</i> nom. prov.	LG481, LG757	Santa Cruz	January, March	
<i>Chroogomphus vinicolor</i>	LG361, LG384, LG616, LG666, LG667, LG744	Both	January, March ^c , April	M
<i>Clavulina cristata</i>	LG746, LG798	Santa Cruz	January	
<i>Clitocybe nuda</i> ^a	LG604	Santa Rosa	March	
<i>Coprinus</i> sp. ^a	LG603	Santa Rosa	March	
<i>Cortinarius</i> cf. <i>fulmineus</i>	LG858	Santa Cruz	January	
<i>Cortinarius</i> cf. <i>obtusus</i>	LG392	Santa Cruz	March	
<i>Cortinarius</i> subgenus <i>Telemonia</i> sp.1	LG394	Santa Cruz	March	
<i>Cortinarius</i> subgenus <i>Telemonia</i> sp.2	LG1014	Santa Cruz	January	
<i>Cortinarius</i> sp.1	LG468	Santa Cruz	March	
<i>Cortinarius</i> sp.2	LG838	Santa Cruz	January	
<i>Cortinarius</i> sp.3	LG569	Santa Rosa	March	
<i>Dermocybe cinnamomeus</i> group sp.1	LG351	Santa Cruz	March	
<i>Dermocybe cinnamomeus</i> group sp.2	LG358	Santa Cruz	March	
<i>Dermocybe</i> cf. <i>croceifolius</i>	LG367	Santa Cruz	March	

Appendix 1. (Continued) Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Dermocybe</i> sp.1	LG383	Santa Cruz	March	
<i>Dermocybe</i> sp.2	LG385	Santa Cruz	March	
<i>Dermocybe</i> sp.3	LG386	Santa Cruz	March	
<i>Dermocybe</i> sp.4	LG500	Santa Cruz	March	
<i>Dermocybe</i> sp.5	LG565	Santa Rosa	March	
<i>Dermocybe</i> sp.6	LG1384	Santa Cruz	January	
<i>Dermocybe</i> sp.7	LG850	Santa Cruz	January	
<i>Entoloma nidorosum</i> group	LG820	Santa Cruz	January	
<i>Entoloma</i> cf. <i>rodopolium</i>	LG355, LG401, LG735	Santa Cruz	January, March	
<i>Entoloma</i> sp.1	LG727	Santa Cruz	January	
<i>Entoloma</i> sp.2	LG783	Santa Cruz	January	
<i>Entoloma</i> sp.3	LG495	Santa Cruz	March	
<i>Entoloma</i> sp.4	LG501	Santa Cruz	March	
<i>Entoloma</i> sp.5	LG542	Santa Rosa	March	
<i>Geastrum fornicatum</i>	LG490	Santa Cruz	March	
<i>Hebeloma</i> sp.1	LG318	Santa Cruz	March	
<i>Hebeloma</i> sp. 2	LG394	Santa Cruz	March	
<i>Helvella</i> cf. <i>compressa</i>	LG419, LG434, LG459, LG589, LG593, LG795	Both	January, March ^c	C, M
<i>Helvella griseoalba</i>	LG546	Santa Rosa	March	
<i>Helvella</i> cf. <i>lacunosa</i>	LG312, LG353, LG395, LG396, LG420, LG441, LG538, LG703, LG704, LG735	Both	January, March ^c	C, M, T
<i>Helvella</i> cf. <i>queletti</i>	LG651, LG740	Santa Cruz	January, April	
<i>Helvella</i> sp.1	LG410	Santa Cruz	March	
<i>Hygrophorus</i> cf. <i>roseibrunneus</i>	LG711, LG712	Santa Cruz	January	
<i>Inocybe geophylla</i>	LG397, LG840, LG869	Santa Cruz	January, March	M
<i>Inocybe</i> sp.1	LG375	Santa Cruz	March	
<i>Inocybe</i> sp.2	LG472	Santa Cruz	March	
<i>Inocybe</i> sp.3	LG322	Santa Cruz	March	
<i>Inocybe</i> sp.4	LG387	Santa Cruz	March	
<i>Inocybe</i> sp.5	LG743	Santa Cruz	January	
<i>Inocybe</i> sp.6	LG872	Santa Cruz	January	
<i>Inocybe</i> sp.7	LG886	Santa Cruz	January	

Appendix 1. (Continued) Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Laccaria amethysteo-occidentalis</i>	LG350, LG428, LG460, LG574, LG831	Both	January, March ^c	
<i>Laccaria</i> cf. <i>amethysteo-occidentalis</i>	LG861, LG950	Santa Cruz	January	
<i>Laccaria bicolor</i>	LG455, LG797, LG884, LG952	Santa Cruz	January, March	
<i>Laccaria laccata</i>	LG456	Santa Cruz	March	
<i>Laccaria</i> cf. <i>laccata</i>	LG832, LG837	Santa Cruz	January	
<i>Laccaria proxima</i>	LG422	Santa Cruz	March	
<i>Laccaria</i> sp. 1	LG398	Santa Cruz	March	
<i>Laccaria</i> sp. 2	LG346, LG443, LG527	Both	March ^c	
<i>Lactarius alnicola</i>	LG1379, LG404, LG702, LG716, LG730	Santa Cruz	January, March	
<i>Lactarius</i> cf. <i>argillaceifolius</i>	LG717, LG1124, LG1127	Santa Cruz	January	M
<i>Lactarius</i> cf. <i>argillaceifolius</i> var. <i>macrocarpus</i>	LG551	Santa Rosa	March	
<i>Lactarius</i> cf. <i>piperatus</i>	LG470	Santa Cruz	March	
<i>Lactarius rubidus</i>	LG309, LG313, LG314, LG316, LG435, LG523, LG561, LG562, LG567, LG587, LG705, LG871, LG1050	Both	January, March ^c	
<i>Lactarius</i> sp.1	LG466	Santa Cruz	March	
<i>Lactarius</i> sp.2	LG596	Santa Rosa	March	
<i>Lactarius xanthogalactus</i>	LG345, LG446	Santa Cruz	March	
<i>Leccinum</i> cf. <i>manzanitae</i>	LG464	Santa Cruz	March	M
<i>Lepiota cristata</i> ^a	LG868, LG867	Santa Cruz	January	
<i>Leptonia</i> cf. <i>parva</i> ^a	LG859	Santa Cruz	January	
<i>Leucopaxillus amarus</i>	LG347	Santa Cruz	March	M
<i>Lycoperdon</i> sp. ^a	LG839	Santa Cruz	January	
<i>Macrolepiota rachodes</i> ^a	LG605	Santa Rosa	March	
<i>Melanoleuca</i> cf. <i>lewisii</i> ^a	LG857	Santa Cruz	January	
<i>Melanoleuca</i> sp. ^a	LG390	Santa Cruz	March	
<i>Microthecium geopora</i> ^a	LG755, LG979	Santa Cruz	January	
<i>Omphalotus olivascens</i> ^a	LG308	Santa Cruz	March	C, T
<i>Otidia</i> cf. <i>alutacea</i>	LG448, LG845, LG866	Santa Cruz	January, March	M
<i>Otidea</i> cf. <i>onotica</i>	LG619, LG620, LG1013	Both	January, March	M
<i>Otidea</i> sp.	LG728	Santa Cruz	January	
<i>Paneolus</i> sp. ^a	LG741	Santa Cruz	January	

Appendix 1. (Continued) Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Peziza</i> cf. <i>sylvestris</i>	LG725	Santa Cruz	January	
<i>Peziza</i> sp.1	LG323	Santa Cruz	March	
<i>Peziza</i> sp.2	LG609	Santa Rosa	March	
<i>Peziza</i> sp.3	LG669	Santa Cruz	April	
<i>Peziza</i> sp.4	LG402	Santa Cruz	March	
<i>Pluteus</i> sp.1 ^a	LG579	Santa Rosa	March	
<i>Pluteus</i> sp.2 ^a	LG564	Santa Rosa	March	
<i>Psathyrella</i> cf. <i>atrofolia</i> ^a	LG756	Santa Cruz	January	
<i>Psathyrella</i> cf. <i>uliginicola</i> ^a	LG324, LG325	Santa Cruz	March	
<i>Ramaria mutabilis</i>	LG873, LG1056	Santa Cruz	January	
<i>Russula</i> cf. <i>amoenolens</i> group	LG403, LG418, LG497, LG526, LG853, LG868, LG1053	Both	January, March ^c	
<i>Russula</i> cf. <i>brevipes</i> group	LG449, LG851	Santa Cruz	January, March	C, M
<i>Russula</i> subgenus <i>Compactae</i>	LG622	Santa Rosa	March	
<i>Russula</i> cf. <i>maculata</i> group	LG438, LG477, LG484, LG486, LG863, LG1054, LG1128	Santa Cruz	January, March	C
<i>Russula</i> cf. <i>sanguinea</i>	LG436, LG1380	Santa Cruz	March	
<i>Russula</i> cf. <i>silvicola</i>	LG1021	Santa Cruz	January	
<i>Russula</i> sp.1	LG487	Santa Cruz	March	
<i>Russula</i> sp.2	LG431, LG462	Santa Cruz	March	
<i>Russula</i> sp.3	LG467, LG473, LG1047	Santa Cruz	January, March	
<i>Russula</i> sp.4	LG541	Santa Rosa	March	
<i>Russula</i> sp.5	LG577, LG581, LG1381	Both	March, January	
<i>Russula</i> sp.6	LG528	Santa Rosa	March	
<i>Russula</i> sp.7	LG1012	Santa Cruz	January	
<i>Russula</i> sp.8	LG585	Santa Rosa	March	
<i>Russula</i> sp.9	LG363b	Santa Cruz	March	
<i>Russula</i> sp.10	LG714	Santa Cruz	January	
<i>Russula</i> sp.11	LG854	Santa Cruz	January	
<i>Russula</i> sp.12	LG1011	Santa Cruz	January	
<i>Russula</i> sp.13	LG1044	Santa Cruz	January	
<i>Russula</i> sp.14	LG1045b	Santa Cruz	January	
<i>Russula</i> sp.15	LG1046	Santa Cruz	January	
<i>Russula</i> sp.16	LG1062	Santa Cruz	January	

Appendix 1. (Continued) Fungal specimens collected on Santa Cruz Island in July 2000, March and April 2001, and January 2002, and Santa Rosa Island in March 2001 and March 2002 compared to collections made by other researchers.

Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Russula</i> sp.17	LG1063b	Santa Cruz	January	
<i>Russula</i> sp. nov.	LG502	Santa Cruz	March	
<i>Sepedonium chrysospermum</i> ^a	LG421, LG731	Santa Cruz	January, March	
<i>Sepedonium</i> sp. ^a	LG330, LG928	Santa Cruz	January, March	
<i>Stereum striatum</i> cf. <i>varochraceoflavum</i>	LG326	Santa Cruz	March	
<i>Suillus pungens</i>	LG374, LG765, LG835, LG844, LG949, LG1512	Santa Cruz	January, March	M
<i>Suillus quiescens</i> nom. prov.	LG359, LG360, LG370, LG372, LG373, LG747, LG748, LG830b, LG885, LG1122	Santa Cruz	January, March	
<i>Thelephora caryophyllea</i>	LG354, LG376	Santa Cruz	March	
<i>Thelephora scissilis</i>	LG1119	Santa Cruz	January	
<i>Tomentella</i> sp.	TDB2950	Santa Cruz	July	
<i>Tricholoma</i> cf. <i>flavovirens</i>	LG371, LG761, LG781, LG1010	Santa Cruz	January, March	
<i>Tricholoma</i> cf. <i>imbricatum</i>	LG778, LG836, LG849, LG1043	Santa Cruz	January	C
<i>Tricholoma</i> cf. <i>portentosum</i>	LG708, LG713	Santa Cruz	January	C
<i>Tricholoma</i> sp.1	LG833	Santa Cruz	January	
<i>Tricholoma</i> sp.2	LG1123	Santa Cruz	January	
<i>Tricholoma</i> cf. <i>ustaloides</i>	LG363	Santa Cruz	March	
<i>Tylopilus</i> cf. <i>indecisus</i>	LG356, LG843, LG1120	Santa Cruz	January, March	
<i>Tylopilus</i> cf. <i>olivaceobrunneus</i>	LG388	Santa Cruz	March	
<i>Tylopilus pseudoscaber</i> group	LG520	Santa Rosa	March	
<i>Tylopilus</i> sp.	LG860	Santa Cruz	January	
<i>Volvariella speciosa</i> ^a	LG721	Santa Cruz	January	C, M
Hypogeous taxa				
<i>Balsamia magnata</i>	LG407, LG821, LG875, LG1113, LG1115, LG1118	Santa Cruz	January, March	
<i>Balsamia nigrens</i>	LG881	Santa Cruz	January	
<i>Balsamia setchellii</i>	LG532, LG613, LG846, LG880	Both	January, March	
<i>Cazia flexiascus</i>	LG423, LG489, LG738, LG1100	Santa Cruz	January, March	
<i>Endogone lactiflua</i>	LG568, LG662, LG780, LG828, LG847, LG883, LG941, LG947, LG948, LG951, LG953	Both	January, March, April	
<i>Geopora cooperi</i>	LG 334, LG752, LG775, LG979, LG1103	Santa Cruz	January, March	

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Species name ^a	Voucher # ^b	Island	Season ^c	Species collected by others ^d
<i>Geopora cooperi</i> var. <i>cooperi</i>	LG340, LG755	Santa Cruz	January, March	
<i>Hydnoplicata ellipsozona</i>	LG378, LG451, LG452, LG453, LG739	Santa Cruz	January, March	
<i>Hymenogaster mcmurphyi</i> nom. prov.	LG729	Santa Cruz	January	
<i>Hymenogaster</i> sp. nov.	LG1382	Santa Cruz	January	
<i>Hysterangium separabile</i>	LG469, LG573	Both	March ^c	
<i>Melanogaster euryzpermus</i>	LG424a, LG737	Santa Cruz	January, March	
<i>Melanogaster</i> cf. <i>tuberiformis</i>	LG328, LG329, LG424b, LG533, LG956, LG981, LG1041, LG1042	Both	January, March ^c	
<i>Melanogaster</i> cf. <i>variegatus</i>	LG406, LG442, LG655, LG976, LG977, LG1065b	Santa Cruz	January, March	M
<i>Radiigera taylori</i>	LG1134	Santa Rosa	March	
<i>Rhizopogon occidentalis</i>	LG331, LG531, LG791	Both	January, March ^c	
<i>Rhizopogon vulgaris</i>	LG339, LG988	Santa Cruz	January, March	
<i>Russula (Macowanites) insularis</i> nom. prov.	LG468, LG475, LG571a, LG876, LG973, LG980, LG1039, LG1051, LG1102, LG1126, LG1048, LG1055, LG1383, LG974, LG1052	Both	January, March ^c	
<i>Russula (Macowanites) santarosana</i> nom. prov.	LG571b, LG758	Both	January, March ^c	
<i>Setchelliogaster tenuipes</i>	LG315	Santa Cruz	March	

^a These are non-ectomycorrhizal species.

^b Specimen voucher numbers are those of Thomas D. Bruns (TDB) or Lisa Grubisha (LG). All collections will be accessioned into the University Herbarium, University of California at Berkeley (UC).

^c These species were collected on both islands in March 2001.

^d Species indicated are only those that overlap with species from our study but were collected by other researchers. Unfortunately there is not enough room here to report all species collected by others. C = R. Cummings. Cummings collected a total of 50 species in January 1984, February 1985, and February 1999 on Santa Cruz (pers. comm.), and 14 species overlap with our collections. M = J. Menge. Menge collected 97 species in May 1981 and March 1982 on Santa Cruz (pers. comm.), but only 25 species overlap with our study. T = H. Thiers. Thiers collected 13 fleshy fungi and many lichens in January 1984 on Santa Cruz (D. Desjardin pers. comm.), and four species overlap with our study.