

1 **Continued survival of the elusive Seram orange melomys**

2 ***(Melomys fulgens)***

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22 **Abstract.** Many poorly-known small mammals have remained undetected for
23 decades, including *Melomys fulgens*, a distinctive orange murid from Seram,
24 Indonesia, that has been unrecorded since 1920. We report previously
25 undocumented specimens of *M. fulgens* collected in 1993 and 1994, and local
26 ecological knowledge from 2017 including descriptions and recent sightings,
27 providing strong indirect evidence of its continued survival in similar habitat to
28 known collection localities. These findings indicate relatively widespread
29 distribution of *M. fulgens* in low-elevation coastal forest across Seram, raising
30 hope for continued survival of Seram's other 'lost' small mammals.

31

32 **Keywords:** extinction, Indonesia, local ecological knowledge, lost species,
33 species rediscovery

34 Determining the status and continued survival of poorly-known species within
35 threatened biodiversity hotspots is an urgent conservation goal. However, 875 of
36 6371 mammal species are listed as Data Deficient by IUCN (2021), and numerous
37 rare mammals remained undetected for decades before rediscovery (Fisher and
38 Blomberg 2011). These concerns are exacerbated for small tropical mammals,
39 which have attracted less search effort and were missing for longer before
40 rediscovery (Fisher 2011), with high concentrations of Data Deficient small
41 mammals within many at-risk tropical landscapes where field research has been
42 limited (Kennerley et al. 2021).

43 A diverse endemic small mammal assemblage is known from Seram, the
44 largest island (17,100km²) in Maluku Province, Indonesia. This includes five
45 rodents (*Melomys aerosus*, *M. fraterculus*, *M. fulgens*, *Nesoromys ceramicus*, *Rattus*
46 *feliceus*), a subspecies of *M. rufescens*, and a bandicoot (*Rhynchomeles prattorum*)
47 (Thomas 1920; Flannery 1995; Helgen 2003). Several invasive small mammals
48 (*Rattus argentiventer*, *R. exulans*, *R. nitidus*, *R. rattus*, *Suncus murinus*) also occur
49 (Macdonald et al. 1993). All endemic non-volant species were described by
50 Thomas (1920), from specimens collected by Felix, Charles and Joseph Pratt in
51 January-February 1920. Three species (*M. fraterculus*, *M. fulgens*, *R. prattorum*)
52 were recorded from single localities and not detected during subsequent surveys
53 (Kitchener et al. 1993; Helgen 2003; IUCN 2021), and are considered 'lost
54 species' (Long and Rodríguez 2022; Martin et al. 2022). Of these, *M. fraterculus*
55 and *R. prattorum* were collected on Mount Manusela and are assessed as
56 Endangered (IUCN 2021), whereas *M. fulgens* was collected near sea-level at
57 Taluti Bay and is considered Data Deficient (Thomas 1920; Helgen 2003) (Figure
58 1).

59 The Seram orange melomys *M. fulgens* is a distinctive orange-coloured murid
60 with a long prehensile tail (see Fabre et al. 2018 for holotype photograph). It
61 “stands out in startling contrast” from other Seram murids (Thomas 1920, p.
62 427), which are dorsally reddish-brown, brown or blackish-brown (Helgen
63 2003). The paratype was caught in a tree near the coast, and its tail morphology
64 suggests it is highly arboreal (Thomas 1920; Flannery 1995; Helgen 2003).
65 Intriguingly, Thomas (1920, p. 427) suggested its coloration might have evolved
66 to mimic the yellow mantles of *Pteropus* bats, “the rat gaining protection by its
67 resemblance to the fruit-bats, which hawks generally leave severely alone”. This
68 hypothesis has not been assessed further, but protective mimicry is very rare in
69 mammals (Eaton 1976; Ancillotto et al. 2022), highlighting the significance of
70 this possible evolutionary interaction.

71 Ecological comparisons across *Melomys* species suggest *M. fulgens* may be
72 adaptable in lowland tropical forests (IUCN 2021). However, no data exist on
73 whether it occurs in modified habitats, or across different localities or elevations.
74 Seram’s lowland forest has been extensively cleared, with recent escalation in
75 deforestation associated with expansion of oil palm plantations and swidden
76 agriculture by plantation workers (Olson 2022). Investigating continued survival
77 of *M. fulgens* is therefore a conservation priority, with the species identified as
78 one of the world’s “most wanted” lost small mammals (Re:wild 2021).

79 We interviewed 32 people (28 men, four women) in six villages along Sawai
80 Bay on Seram’s north coast in July-August 2017 (Huaulu, Masihulan, Olong,
81 Oping, Rumah Olat, Sawai; Figure 1), using a questionnaire about knowledge of
82 local wildlife and forest activities that took c.30 minutes to complete
83 (Supplementary Information File 1). Respondents were selected through

84 opportunistic sampling and snowball sampling, whereby interviewees were
85 asked to identify other people considered knowledgeable about wildlife.
86 Interviews were conducted 1-on-1 in Indonesian by TEJ and colleagues; although
87 this was not the first language of most respondents, they could communicate
88 fluently and answer all questions. Respondents were aged between 22-69
89 (mean: 46), and most (27/32) self-identified as farmers. Villages were situated
90 within 1km from forested areas, and all but one respondent reported visiting
91 nearby forest at least once a week (mean: 4.7 visits/week), to tend forest
92 gardens, hunt, and collect non-timber forest products. Respondents were asked
93 about recognition, knowledge and sightings of mammals, using photos from
94 www.arkive.org and www.naturepl.com of locally-occurring wild mammals
95 (*Spilocus maculatus*, *Phalanger orientalis*, *Rusa timorensis*, *Sus scrofa*, *Rattus*
96 *rattus*, *Suncus murinus*, *Paradoxurus hermaphroditus*, *Viverra zibetha*;
97 Kitchener et al. 1993; Macdonald et al. 1993), *Echimypera rufescens* (absent, but
98 resembles *Rhynchomeles prattorum*), and non-native mammals representing
99 negative controls to assess respondent accuracy (*Dactylopsila trivirgata*,
100 *Dorcopsis muelleri*, *Notamacropus rufogriseus*, *Pongo pygmaeus*, *Macaca*
101 *fascicularis*, *Babyrousa celebensis*, *Manis pentadactyla*). When shown the rat
102 photo, respondents were also asked how many types of *tikus* (Indonesian for
103 rat/mouse) occurred on Seram and to describe them. Additional data on other
104 species will be published elsewhere.

105 Information about small mammals varied in quality, with most respondents
106 only describing invasive murids associated with human dwellings and/or non-
107 diagnostic brown/grey rodents. Several respondents misidentified *Suncus* and
108 *Echimypera* as house rats. Although three respondents volunteered information

109 about a native mammal called *mapeya* (i.e. “mabaya”, local name for bandicoot;
110 Thomas 1920), which two described as having characteristics of both rat and pig,
111 one provided no information on its status, and the other had only heard about it
112 from his grandfather and great-grandfather, who lived on Mount Manusela; the
113 third provided a fantastic description.

114 However, seven respondents from two villages (six from Masihulan, 65m asl;
115 one from Oping, 20m asl) reported a local murid matching *M. fulgens*. This
116 animal was called *lapi-lapinye* or *micinye* by two respondents; this is possibly
117 similar to *mirine*, a name used in south Seram for an unidentified murid (Ellen
118 1993). It was consistently distinguished from other rodents by its yellow
119 coloration (reportedly yellow all over, or yellow dorsally and whitish/dull
120 ventrally). Two respondents also described a long tail (similar length to body, or
121 long relative to body). All respondents said it lived in forest and/or was observed
122 in trees (named trees were non-native, including candlenut, cacao, clove,
123 coconut, cinchona and sago); one respondent specifically called it the yellow tree
124 rat, another stated it lives in clove trees, and three sightings were in trees near
125 the beach. Interestingly, one respondent provided independent support to
126 Thomas’ (1920) suggestion about colour mimicry, stating the yellow rat lives
127 alongside yellow fruit bats, with bats making holes in fruit and the rats feeding
128 on the fruit afterwards. Although one respondent reportedly saw the species
129 often at night, four thought it was rare, with one adding it had become rarer.
130 Last-sighting dates ranged between four months and 10 years earlier; these
131 dates were older than last-sighting dates from the same respondents for
132 *Spilocus maculatus*, *Phalanger orientalis*, *Rusa timorensis*, *Sus scrofa* and
133 *Viverra tangalunga* (all seen within the past year, and typically the previous few

134 weeks). Compared to other respondents, those who reported yellow rats were
135 not statistically older (one-tailed t-test, $p=0.430$) and did not spend more time in
136 the forest (one-tailed t-test, $p=0.478$), but none misidentified control species as
137 occurring on Seram (unlike three other respondents).

138 In addition to these reports, three previously unrecorded *M. fulgens*
139 specimens (two males, one female) were collected by AAM and colleagues on
140 Seram in 1993-1994, confirming the species' survival into recent decades (head-
141 body length, 172-200mm; tail, 175-191mm; mass, 147-154g; Figures 2-3;
142 Supplementary Information File 2). Specimens were collected from Melinani
143 hamlet, a lowland forest area (c.6 hectares, 60-70m asl) within Manusela village,
144 Seram Utara district (Figure 1). All were caught in trees; the final individual was
145 caught in open forest behind a house in an area where cows grazed, containing
146 c.13m trees with overlapping crowns that allowed arboreal movement between
147 them. Local people reported the animal was abundant in areas with large forest
148 trees and occurred from sea-level to 1200m asl, and could leap between trees,
149 ran rapidly along branches and sometimes came to the ground, where it was said
150 to hop rather than run.

151 The 1993 male was preserved in alcohol and deposited at the Bogor Zoology
152 Museum; this specimen cannot now be located. The 1993 female and 1994 male
153 were prepared as skins and skeletons and registered in the collection of National
154 Museums Scotland (accession numbers NMS.Z.1995.153.3, NMS.Z.1995.153.4;
155 Figure 2). Both specimens have gingery orange fur, darkening dorsally along the
156 midline. The underside is white and sharply demarcated from the ginger fur,
157 continuing along the insides of the limbs onto the upperside of each paw and
158 underside of the head, including the lower jaw. The whiskers are long and black.

159 Upon dissection, a foetus was found in the female specimen's right uterine horn
160 and preserved in alcohol.

161 Establishing continued survival of rare or elusive species from anecdotal
162 reports can be problematic, and risks promoting inappropriate conservation
163 planning if identifications are not secure (McKelvey et al. 2008). However, we
164 demonstrate definite survival of *M. fulgens* into the 1990s, over 70 years since its
165 only previous record; and provide strong indirect evidence of its continued
166 survival in similar habitat to known collection localities, with detailed local
167 reports highly unlikely to represent other regionally-occurring rodents. Only 15
168 other small-bodied non-volant mammals still considered possibly extant have
169 remained undetected since before 1920 (Martin et al. 2022). Our findings
170 indicate relatively widespread distribution of *M. fulgens* in coastal forest across
171 Seram, including sites adjacent to Manusela National Park (Figure 1), with local
172 suggestions that it occurs throughout the lowland forest zone to its upper
173 elevational limit at 900-1200m (Monk et al. 1997), although this requires
174 confirmation. However, based upon the limited known localities and continuing
175 loss of Seram's lowland forest, we propose a new Red List assessment of
176 Vulnerable B1a,biii. This rediscovery raises hope for continued survival of
177 Seram's other 'lost' mammals, although recent extinction of another *Melomys*
178 species, *M. rubicola* (Waller et al. 2017), highlights their vulnerability within
179 increasingly human-impacted landscapes. Our results provide a new example of
180 the usefulness of local ecological knowledge to detect distinctive small mammals
181 in poorly-studied regions, and promote the need to focus on neglected tropical
182 small mammal diversity.

183

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189

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193 **Conflict of interest statement.** We have no conflicts of interest.

194

195 **Compliance with ethical standards.** Research design for fieldwork involving
196 human participants was approved by Durrell Wildlife Conservation Trust's
197 Ethics Committee (ETH22/04). Written informed consent for participation was
198 not required in accordance with national legislation and institutional
199 requirements; participation was voluntary, and verbal consent was obtained
200 from all participants following explanation of study aims and that interviews
201 were anonymous. Research was conducted under LIPI Surat Izin Penelitian
202 4619/V3/KS/1993 and 4187/II/KS/1994. All field activities were conducted in
203 accordance with Indonesian national laws.

204

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260 **Figure 1.** Map of Seram, showing collection locations of *Melomys fulgens*
261 specimens and reports, and boundary of Manusela National Park.

262

263 **Figure 2.** *Melomys fulgens* specimens in National Museums Scotland. **A,**
264 NMS.Z.1995.153.4, male, caught 20 August 1994. **B,** NMS.Z.1995.153.3, female,
265 caught 24 August 1993.

266

267 **Figure 3.** Male *Melomys fulgens*, caught 20 August 1994.