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Restoration of locality and elevation data to bird-specimens from Kaua‘i, collected by Munro and Palmer, by reconstructing their Makaweli Camp collecting locality

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Abstract. Using George C. Munro’s transcribed field diary (30 December 1890–16 February 1891), Munro’s article on *Notes on some Kauai birds* from 1947, Rothschild’s *Birds of Laysan*, and late 19th/early 20th-century cartography, we reconstructed the location of the temporary camp site in the Makaweli uplands west of Waimea, Kaua‘i used by Munro and Henry C. Palmer. Independent constraints from the diary converge on Gay & Robinson pasture lands in the vicinity of the modern Kepani Reservoir (inferred elevation 1,100–1,300 ft [335–396 m]). Munro’s diary lists the camp elevation as 1,800 ft [549 m], implying a systematic overestimate of 500–700 ft [152–213 m]. The nearby Nonapahu Ridge was frequently visited, but the summit Kaupū‘a‘a at 2,863 ft [873 m] was never reached. These findings restore the elevational provenance of 200+ bird specimens collected during their stay. It requires correction of associated data and makes explicit the constraints for analyses of species that are elevation-sensitive.

INTRODUCTION

Accurate locality and elevation data are essential for interpreting historical biological collections because elevation, microhabitat and geographic isolation strongly influence species distributions, phenotypic variation and genetic structure. Elevation-limited disease vectors such as mosquitoes drive the upper elevational bound of avian malaria and pox, so establishing the elevation on which specimens were collected is essential to avoid systematic bias in disease-range and vulnerability assessments. The majority of late 19th-century Kaua‘i specimens lack precise locality data, reducing their utility for modern ecological, genomic and conservation research. The 314-page field diary of George C. Munro (transcribed and archived by the Bernice Pauahi Bishop Museum) provides unusually detailed route descriptions, habitat notes and logistical observations of the fieldwork by him and Henry C. Palmer on Kaua‘i in 1890–1891 (Towill 2001). These are for the most part only labelled Kaua‘i. We used the diary, contemporary Rothschild notes and historical maps to (1) reconstruct camp locations, (2) quantify any elevation discrepancy between diary entries and modern topography, and (3) assess consequences for specimen provenance.

MATERIALS AND METHODS

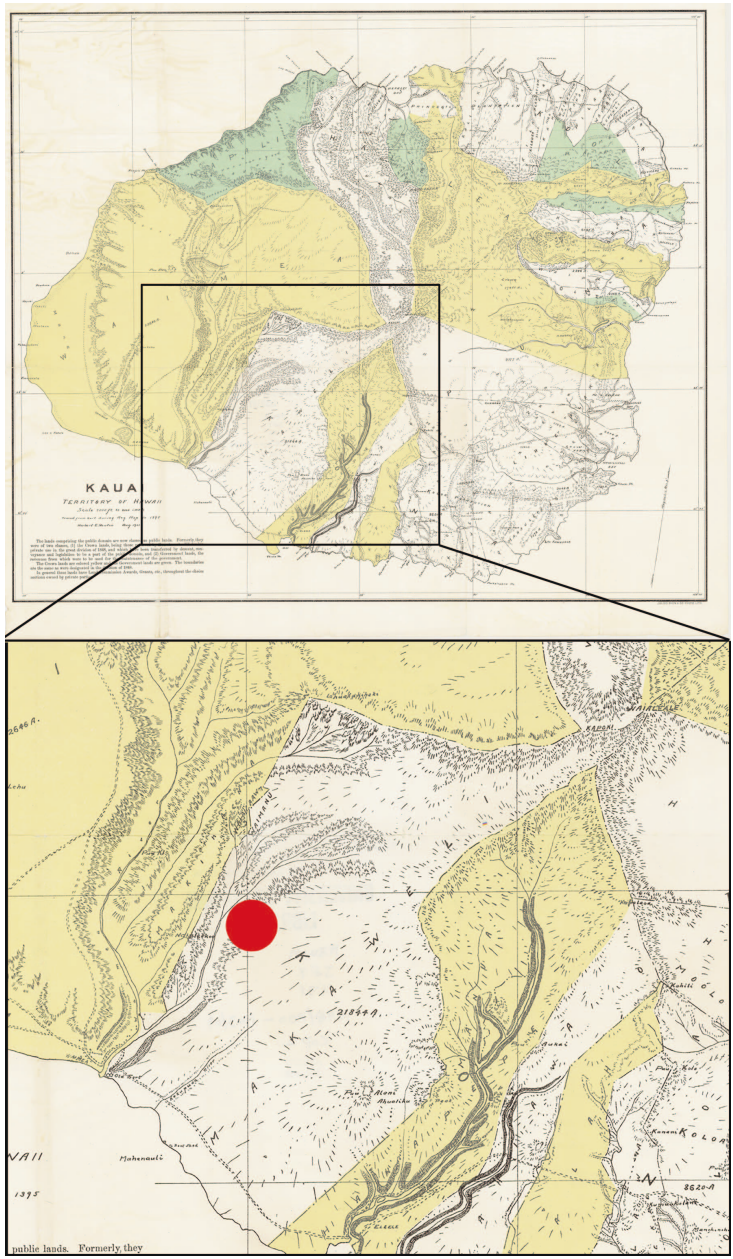
We treated Munro's transcribed diary (period 30 December 1890–16 February 1891) as the primary source. Historical cartography consulted included Alexander (1878), Emlay (1891), Newton (1901, 1908), Wall (1903) and the Geological Survey 1910 map series. We furthermore used pastoral records from the landowners Francis Gay and Aubrey Robinson as well as contemporary land-use descriptions. From Munro's diary we extracted discrete spatial and environmental constraints: route geometry and travel times from Waimea, vegetation sequences, presence of livestock and cattle, presence of certain tree species (e.g., *Aleurites moluccanus, Psidium guajava, Citrix* × *sinensis*), hydrological features (stream junctions, ponds), microtopography (valley drops, terraces), visibility claims (view toward the ʻEleʻele sugar plantation), presence of a bridal track to the highest point on the island, named local residents and land ownership. Each diary statement was treated as a spatial constraint and intersected on historical maps to identify candidate areas; the final placement was selected where all independent constraints co-occurred. Modern digital elevation models (DEMs) and contour data were used to compare Munro's recorded elevation with present-day topography at the inferred site. Museum specimen records associated with the diary period were mapped to the reconstructed polygon to propose updated locality assignments and to quantify the number of affected specimens.

RESULTS

Camp location and elevation discrepancy

Diary entries describe travel from Waimea up the west bank of the Waimea River to the Makaweli confluence, then approximately two miles up Makaweli where rice and taro cultivation was recorded and the river narrowed. From that point a westward road ascended into upland pasture; the approach vegetation changed from twitch grass to Buffalo grass, scrub diminished, and cattle and kukui *Aleurites moluccanus* trees were encountered. Travel times recorded in the diary (2.5–4.0 hours on horseback) and a stated camp distance of seven to eight miles from Waimea constrain the camp to the lower upland ridge system west of Makaweli Valley. Close to the camp is a bridle track running from Waimea (Kekupua) to the highest point on the island: Kawaikini (cf. Emlay 1891, Geological Survey 1910). Additional diary details, such as orange and guava trees in the vicinity, bare brown soil to the west, proximity to Gay & Robinson property and to residencies of, for instance, "Portuguese" Joe Morgard and his son, further narrow the candidate area.

When all constraints are combined, the only area satisfying most environmental, topographic, logistical and historical conditions is the Gay & Robinson-owned upland pasture area on the Makaweli-Pāpanahoa ridge system, near the confluence of small Makaweli tributaries and adjacent to Nonapahu Ridge. The reconstructed campsite location (see Map 1) lies in the immediate vicinity of the modern Kepani Reservoir (approximately 1,100 ft [335 m]) and is adjacent to the feature labelled Camp Nine on the Geological Survey 1910 map. Munro's diary records the camp elevation as 1,800 ft, but modern DEMs and contour mapping at the inferred site indicate elevations of approximately 1,100–1,300 ft [335–396 m], yielding a discrepancy of roughly 500–700 ft [152–213 m]. We assume that Camp Nine was established after Palmer's visit because it is absent from maps from the period 1878–1901, and the area's environmental features show alterations consistent with conversion to agricultural use.



Map 1. Map of Kauaʻi. Red dot in the detail map denotes the location of the camp of Palmer and Munro in the Makaweli uplands during 30 December 1890–16 February 1891. Map source: Newton (1901).

Additionally, Munro (1947) noted that the old hunting ground was situated above the Hanapēpē Valley and the forest above Olokele Sugar Mill on the side of a branch of the Hanapēpē canyon. This points to the same general area as described above, so does not conflict.

Toponymic uncertainty

Munro's diary records a "road westwards" from the Makaweli approach; however, no westward road exists in the mapped or modern landscape, and even if Waimea Canyon Drive were interpreted as the referenced route, it does not lead to pastoral lands or fruiting trees as described in the diary. The two local names cited, Kalaukawaii and Pupukiniu, could not be phonetically or geographically correlated with any documented localities in the broader Waimea region (Coulter 1935, Pukui *et al*. 1974), indicating a substantive incongruity between the indigenous nomenclature and its English rendering. Consequently, we excluded these names from our spatial search to avoid introducing spurious candidate areas, and we placed greater weight on the accuracy of all other diary features.

We have a photograph from 1893 of the Gay and Robinson-family at the Makaweli House at an uphill locality (which is called Pupukiniu according to Munro), but its precise location has not been determined (but it is not the Pākalā house which is at a coastal location). It is known that 'Pupukiniu' overlooked the Makaweli coast and the uplands above Waimea. This house was also visited by Perkins (Evenhuis 2007: 229-230).

Ridge visits

From the camp, the party made repeated excursions onto the Nonapahu Ridge immediately east of the camp. Early visits were concentrated on the west-hand (camp) side of the ridge, with later traverses extending westward along the ridge crest. Munro's entries indicate ridge traverses without confirming ascent to the nearby summit Kaupū'a'a (2,863 ft [818 m]).

Specimens

During their stay from 30 December 1890–16 February 1891, Munro and Palmer collected 270 bird specimens that can now be reassigned to the reconstructed upland polygon; specimens collected during ridge traverses span a broader elevational gradient and therefore carry greater elevational uncertainty than those collected on short near-camp forays.

With the camp location now determined plus the information in Munro's diary, we could group the birds into a small set of discrete elevation bands (Table 1). Specimen collecting often started at the camp, which resulted in overlapping bands starting from 1,100 ft [335 m]. Especially the signal for higher elevations is therefore diluted. The strongest signal is a pronounced concentration of records at 1,100–1,200 ft [335 –366 m], which contains the majority of observations and the greatest species richness in the dataset. As the camp was situated at this elevation, this signal reflects the specimens collected in the immediate environs of the camp.

Introduced species to Kaua'i, *Gallus gallus* and *Haemaorhous mexicanus*, were only collected at lower altitudes (up to 1,200 ft [366 m]). The species naturally occurring on Kaua'i were encountered along the whole gradient. *Asio flammeus* seems to be restricted to the lower elevations (up to 1,600 ft [488 m]). It is interesting to note that *Oreomystis bairdi*, a species nowadays associated with high elevations, was collected at the lowest altitudes as well.

Table 1. Bird species recorded within defined elevation bands. Species are listed for each elevational range based on occurrences in the dataset, with notes indicating whether taxa were restricted to a band or shared across multiple ranges.

Elevational range	Species observed	Exclusivity note
400–1100 ft [122–335 m]	*Gallus gallus; Drepanis coccinea; Myadestes myadestinus; Psittirostra psittacea; Chasiempis sclateri; Haemorhous mexicanus; Oreomystis bairdi; Akialoa stejnegeri; Asio flammeus*	Mostly shared with higher bands; no clear single-band specialists.
1100–1200 ft [335–366 m]	*Myadestes myadestinus; Chasiempis sclateri; Magumma parva; Himatione sanguinea; Drepanis coccinea; Chlorodrepanis stejnegeri; Haemorhous mexicanus; Psittirostra psittacea; Pluvialis fulva; Akialoa stejnegeri; Moho braccatus; Gallus gallus; Oreomystis bairdi; Asio flammeus; Hemignathus hanapepe*	Dominant sampling band. Many species recorded here; some appear only here in the file but most are also present in other bands.
1100–1400 ft [335–427 m]	*Psittirostra psittacea; Akialoa stejnegeri; Oreomystis bairdi; Moho braccatus*	Shared with 1100–1200 and broader 1100+ bands.
1100–1600 ft [335–488 m]	*Chasiempis sclateri; Moho braccatus; Magumma parva; Drepanis coccinea; Myadestes myadestinus; Psittirostra psittacea; Himatione sanguinea; Asio flammeus; Akialoa stejnegeri*	Shared with 1100–1200 and broader 1100+ bands.
1100-2000 ft [335–610 m]	*Chlorodrepanis stejnegeri; Drepanis coccinea; Akialoa stejnegeri; Moho braccatus; Chasiempis sclateri; Himatione sanguinea; Hemignathus hanapepe*	Broad mid-elevation band; species overlap with narrower 1100+ ranges.
1100–2400 ft [335–732 m]	*Chasiempis sclateri; Chlorodrepanis stejnegeri; Myadestes myadestinus; Psittirostra psittacea; Himatione sanguinea*	Broad high band; species overlap with other 1100+ ranges.
1100–2863 ft [335–818 m]	*Magumma parva; Chasiempis sclateri; Drepanis coccinea; Hemignathus hanapepe; Psittirostra psittacea; Moho braccatus; Pluvialis fulva; Myadestes myadestinus; Himatione sanguinea; Chlorodrepanis stejnegeri*	Very broad span used for records that cover low to very high elevations; species here are also recorded in narrower bands.

DISCUSSION

We consider our reconstruction of the campsite locality of Munro and Palmer robust because multiple independent constraints converge on a single upland sector, like route geometry, travel time, vegetation sequence, hydrology, visibility and human landmarks. These outweigh potential limitations such as changed land use since 1890, wrong directions in the road taken, phonetically recorded toponyms in the diary that could not be matched with certainty, and the possibility that Munro's elevation estimates are in error. Our reconstruction campsite locality at 1,100–1,200 ft [335–366 m] indicates an overestimate of 500–700 ft [152–213 m] compared to Munro's estimates. This finding has implications for analyses that depend on accurate elevational provenance. Human estimates can therefore never replace accurate elevation measurements.

CONCLUSION

Synthesis of Munro's diary and historical cartography places the Munro–Palmer campsite in the upper Makaweli uplands on Gay & Robinson pasture lands west of Makaweli Valley, in the immediate vicinity of Kepani Reservoir (~1,100–1,300 ft [335–396 m]) and adjacent to Camp Nine (Geological Survey 1910). A notable elevation discrepancy between Munro's diary (1,800 ft [549 m]) and modern topography (~1,100–1,300 ft [335–396 m]) requires correction when using specimens collected during their stay there for elevation-sensitive research. The nearby Nonapahu Ridge and summit Kaupū‘a‘a (2,863 ft [873 m]) account for ridge-associated specimens with broader elevational uncertainty. Implementing the recommended GIS verification, archival follow-up, specimen relabelling and field reconnaissance will substantially increase the scientific value of these historical collections for contemporary ecological, genomic and conservation studies.

Observations of most species cluster strongly at 1,100 ft [335 m] but the signal was overall very weak. The little signal probably reflects the limitations on data where specimens were exactly collected. Unknown discrepancies between true and proposed collection localities may have altered conclusions about elevational distribution considerably. After establishing the field camp locality and verifying each specimen's collection locality (georeferenced coordinates) and collection date, we appended complete georeferenced metadata to all 200+ specimens, originally labeled only as "Kauai", thereby bringing the series into compliance with documentation standards required for further analyses.

The identification of collecting localities and their associated features provide a baseline for subsequent work. For this particular locality, future research may use the associated data to evaluate changes in for instance species occurrence and habitat association over time. For instance, since Wilson, private collector R.C.L. Perkins collected in the Makaweli area in May–June 1894, May–June 1895 and January–February 1897 (cf. Evenhuis 2007). For January–February 1897, it is known that Perkins camped in a tent fixed by Francis Gay somewhere between Hanapepe and Makaweli Gulch, which may have been the same location (although its altitude is given as approximately 2,000 ft [610 m] (Evenhuis 2007: 345–356)). It may thus be useful to compare his collections with those made by Wilson 6 years earlier.

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