

## Five New Species of Hawaiian Endemic Fancy Case Caterpillars from a Recently Established Forest Reserve on Maui (Cosmopterigidae: *Hyposmocoma*)

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**Abstract.** We here describe five new species of Hawaiian fancy case caterpillars, *Hyposmocoma* Butler (Lepidoptera: Cosmopterigidae), from East Maui: *Hyposmocoma (Hyposmocoma) starrorum* sp. n., *H. (H.) kukilakila* sp. n., *H. (H.) makaohuna* sp. n., *H. (H.) kamehamenui* sp. n., and *H. (H.) desilvai* sp. n. They were collected during biodiversity surveys of the recently established Kamehamenui State Forest Reserve. All newly described species are endemic to East Maui, and likely even restricted to particular parts of Haleakalā. They represent a fraction of the undescribed diversity in the endemic genus *Hyposmocoma* and the discovery of these new species suggests that conservation initiatives and access to reserves will reveal significant additional diversity in one of Hawai'i's most diverse adaptive radiations.

**Keywords:** taxonomy, biodiversity, Pacific, conservation, fancy case, predatory caterpillar

In 2020, 3,433 acres of land on the northwest slope of Haleakalā in East Maui that were previously part of the Erehwon Ranch were acquired by the State of Hawai'i Division of Forestry and Wildlife; in 2021 this land became Kamehamenui Forest Reserve (FR) (Figure 1). The reserve is adjacent to Haleakalā National Park (NP) and Kula FR, and is envisioned to become part of a *mauna lei* (lit., mountain garland): a band of forest that encircles Haleakalā, with important ecological roles like providing habitat for endangered species and feeding aquifers (DLNR 2021). To establish a baseline biodiversity estimate prior to reforestation efforts, botanical and entomological surveys were carried out by Kim and Forrest Starr (Starr Environmental) in which they collected larvae of several species of *Hyposmocoma* Butler. *Hyposmocoma*

is a hyperdiverse moth genus endemic to the Hawaiian Islands with 352 described and many more undescribed species (Zimmerman 1978, Haines et al. 2014, Medeiros et al. 2017). Almost all are single-volcano endemics, often further restricted by particular habitat conditions; for example, occurring exclusively in wet, mesic, or dry forest, and/or requiring the presence of features like streams, exposed rocks, or specific plants (Schmitz and Rubinoff 2011a, 2011b). The common name for the group, fancy case caterpillars, refers to a remarkable habit of subgenus *Hyposmocoma*: the larvae spin cases in which they reside and build as they grow. Different lineages make different cases, each with a particular shape, often with ornate decorations, that can be used for identification (Haines et al. 2014). Several different types of cases were collected



**Figure 1.** Map of East Maui with the 3,433 acres of Kamehamenui Forest Reserve indicated in red. Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

from Kamehamenui FR and brought to the Insect Systematics and Biodiversity Lab at the University of Hawai'i at Mānoa, where they were reared out. We describe here five new species of *Hyposmocoma* (*Hyposmocoma*) primarily based on this material.

### Material and methods

**From collecting to collections.** *Hyposmocoma* larval cases were visually searched for along two transects in Kamehamenui FR; the first starting at N 20.7547 E -156.3074, el. 1139 m and ending at N 20.7420 E -156.2834, el. 1727 m, and the second starting at N 20.7313 E -156.2867, el. 1890 m and ending at N 20.7258 E -156.2713, el. 2440 m. The searching covered as many microhabitats as possible, including but not limited to, on and under rocks, on various plant parts, under tree bark, and in rotting plant material. Cases were collected by hand or forceps once detected. GPS locations on specimen labels were written as the midpoint of each respective transect. Label data of other specimens is provided verbatim under material examined. We sorted field-collected cases by type, placed them in uniquely

labeled individual Petri dishes, and offered them shaved carrot and fish flakes for food, which was changed every other day. Emerged moths were pinned and spread, and after drying, double mounted and labelled in a standard fashion. We prepared permanent glass slides of the genitalia using standard procedures for small Lepidoptera (e.g., Robinson 1976). Genitalia were stained with a combination of Eosin Y and Chlorazol Black and slide-mounted in Euparal. Photographs of specimens and genitalia slides were taken with a MacroPod PRO 3D camera setup (Macroscopic Solutions, East Hartford, CT) using a Canon MPE 65 mm lens. We took 20–60 photos that were subsequently merged into a final hyperfocal photo using Zerene Stacker (Zerene Systems, Richland, WA). Forewing length was measured in a straight line from the base of the forewing to apex estimated to the nearest tenth-millimeter. Morphological terminology follows Zimmerman (1978), with the following exceptions: we refer to the “aedeagus” as the “phallus” per Kristensen (Kristensen 2003), we refer to the “proboscis” as the “haustellum”, and instead of “genital flaps” we use “pleural lobes” for the dorsoventral lobes emerging from sternite VIII, a term more widely used across Cosmopterigidae (Koster and Sinev 2003). We consider the brachia (arms) as parts of a bifid uncus, and regard the gnathos as lost in Cosmopterigidae (Hodges 1998, Kaila 2004, Koster 2015). We refer to the “pseuduncus” as a “sternite sclerotization,” or, when protruding laterally, a “sternite hook”, and treat it under the pregenital segments of the abdomen.

**DNA extraction.** For DNA extractions we followed an adapted version of the non-destructive protocol from Knölke et al. (2005) that was previously successfully applied to small moths of the family Nepticulidae (details in Doorenweerd et al. 2017). In short, this protocol uses

commercially available DNA extraction kits as a base. The abdomen of a pinned moth was carefully broken off and placed in lysis buffer, and after lysis, the remainder, which included the abdominal cuticle and the sclerotized parts of the genitalia, was removed from the lysis liquid and examined and/or slide mounted. The lysis solution was then used for DNA extraction as per the kit instructions. We used a NucleoMag 96 Tissue magnetic bead kit (Macherey-Nagel, Bethlehem, PA). The lysis step was carried out in individual tubes, the remainder of the extraction protocol was automated in 96-well plates on an OT-2 liquid handler (Opentrons, Long Island City, NY). The final elution was in 100 µl and extracts are stored at -80°C at the University of Hawai'i Insect Museum (UHIM).

**PCR and sequencing.** For molecular identification purposes, we amplified a 1,494 base pair (bp) target fragment of the Cytochrome C Oxidase I gene (COI) using the forward primer LepF (5' ATTCAACCAATCATAAAGATATTGG 3') (Hebert et al. 2004) and reverse primer PatII (5' TCCATTACATATAATCTGC-CATATTAG 3') (Caterino and Sperling 1999). The primers additionally included a unique "barcode" sequence tag to allow them to be pooled for multiplex sequencing on a PacBio Sequel II system, using the tagging scheme (as in Garzón-Orduña et al. 2020). For PCR we used Q5 hot-start high fidelity 2x DNA polymerase (New England BioLabs, Ipswich, MA) with the manufacturer's recommended PCR program and reagent mix for 16 µl reactions. Annealing temperature was set at 55°C. PCR products were visualized on a 1% agarose gel, and pooled together per plate and cleaned with AMPure beads (Beckman Coulter, Indianapolis, IN). Sequencing was outsourced to University of California Berkeley (Berkeley, CA). We created consensus sequences of the raw

reads using the script ccs v6.4.0 (<https://github.com/PacificBiosciences/ccs>) using a 250 base pair minimum length threshold and a .99 minimum predicted accuracy. The resulting consensus sequences were demultiplexed with Mothur v1.42.0 (Schloss et al. 2009), aligned to a reference COI sequence in Geneious R10 ([www.geneious.com](http://www.geneious.com)) and manually inspected for ambiguity. Pairwise distances were calculated using PyCOIStats v1.4.3 (Doorenweerd 2022). The COI sequence data is made available as a Barcoding of Life Datasystems dataset (DOI: [dx.doi.org/10.5883/DS-5MAUIHYP](https://doi.org/10.5883/DS-5MAUIHYP)), this dataset includes sequence data from previous *Hyposmocoma* publications (Haines et al. 2014, Medeiros et al. 2017) and includes collecting details on the voucher specimens. Newly generated COI sequences are additionally made available on NCBI Genbank, accessions OQ611459–OQ611782.

**Acronyms for depositories.** NCBI: National Center for Biotechnology Information, United States; UHIM: University of Hawai'i Insect Museum, Honolulu, Hawai'i, United States; BPBM: Bernice Pauahi Bishop Museum, Honolulu, Hawai'i, United States.

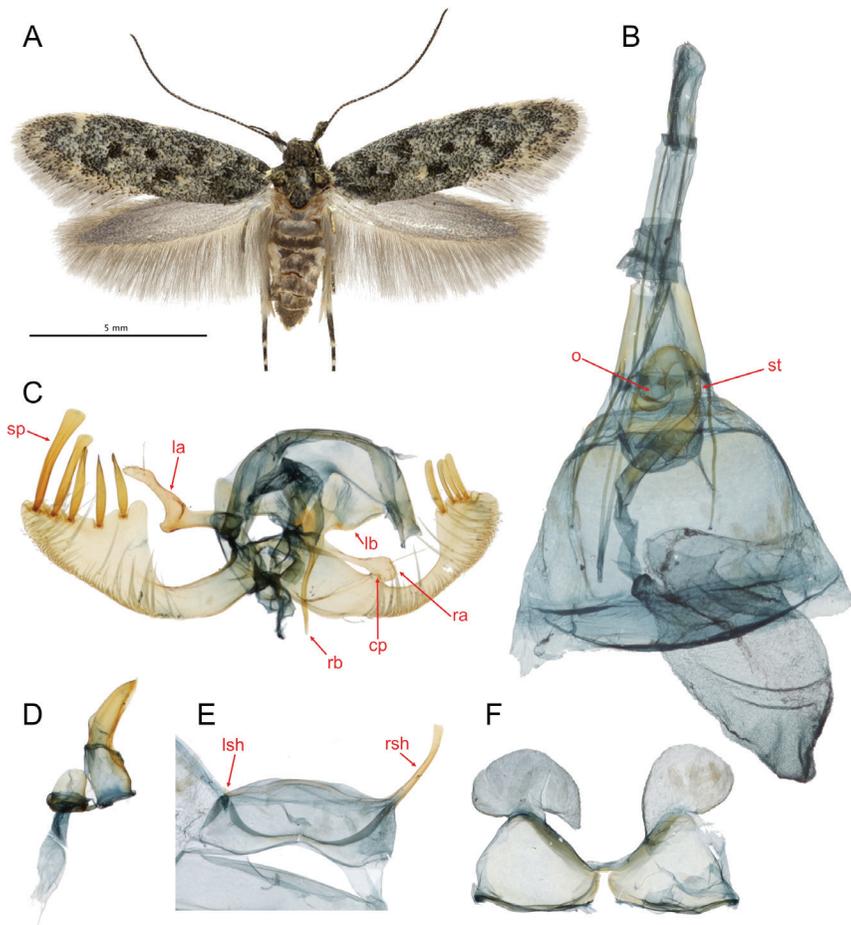
## Taxonomy

### *Hyposmocoma (Hyposmocoma) starrorum* sp. n.

<https://zoobank.org/6F4D4FBF-9DC3-486C-8BE2-797BD3E366A1>  
Figs. 2, 6D.

### Type material

**Holotype.** Male. USA: HI: Maui 3.v.2021 DR21E1A.E8, Kamehamehenui F[orest] R[eserve] Hand coll.[ected] Burrito cases. E.[x]l.[arva] 24.vi.2021, N 20.7524 E -156.2722 2135 m. Leg. Forest and Kim Starr. DNA extract: DNA00319. Genitalia slide: KAA0897. UHIM. **Paratypes.** 17 males, 11 females



**Figure 2.** *Hyposmocoma starrorum* sp. n. A. Holotype adult male DR21E1A.E8, DNA00319, reared from a “burrito” type case from Kamehamenui FR. B. Female genitalia, slide KAA0898. C. Male holotype genitalia, valvae and tegumen (right brachium folded over right valva), slide KAA0897. D. Phallus and ductus ejaculatorius, slide KAA0897. E. Sternite hooks on segment VII, slide KAA0897. F. Pleural lobes on sternite VIII. Abbreviations: sp = spur, la = left anellus lobe, ra = right anellus lobe, lb = left brachium, rb = right brachium, cp = costal process, o = ostium, st = sterigma, lsh = left sternite hook, rsh = right sternite hook.

total. 11 females, 7 males, same data as holotype, emerged between 7.vi–20.vii.2021, DNA extracts: DNA00256, DNA00264, DNA00292, DNA00320. Genitalia slide: KAA0898 (female). 6 females, 4 males, USA: HI: Maui 1.vi.2021 DR21F3A, Kamehamenui FR Hand coll.[ected] Burrito

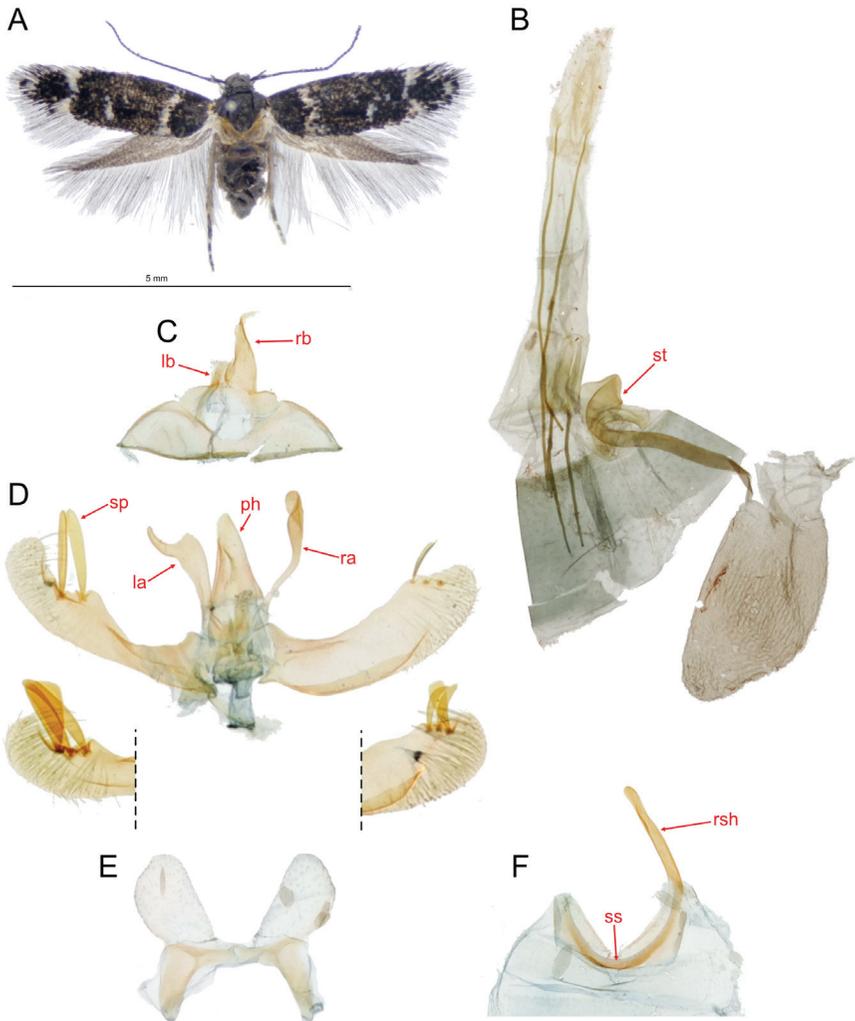
cases. E.[x]l.[arva] 28.vi–26.vii.2021. N 20.7420 E –156.2834 1220m. Leg. Forest and Kim Starr. DNA extracts: DNA00296, DNA00316, DNA00317. 24 deposited in UHIM, 4 in BPBM.

**Diagnosis.** Endemic to East Maui. Adults are externally easily confused

with various burrito cased species, such as *H. kaupo* Schmitz and Rubinoff, also present on East Maui. *Hypsmocoma starrorum* can be distinguished by the male genitalia: in *H. starrorum* the left valva is apically broadened, forming a distinct triangular shape, whereas the left valva of *H. kaupo* is not broadened in such a way. The male genitalia of *H. starrorum* are most similar to those of *H. kapakai* Schmitz and Rubinoff, endemic to O'ahu, which also has a similar wing pattern, but *H. kapakai* has a much larger costal process on the right valva; extending 0.5x the width of the valva (note the image of the male genitalia is flipped horizontally in (Schmitz and Rubinoff 2008)). The female genitalia of *H. kaupo* have the anterior apophyses approximately 0.3x the length of the posterior apophyses, whereas they are of about equal length in *H. starrorum*. COI sequence data separates *H. starrorum* from all other described and sequenced species in this group, minimum pairwise distance to nearest neighbor 7.45%.

**Description. Male. Head.** Frons and vertex olive base color with cream mottling. Anterior basal part of haustellum with cream and black scales. Labial palpus with all palpomeres mostly black with some cream mottling, terminal two palpomeres of about equal length. Antenna length roughly equal to forewing. Antennomeres brown with cream-colored apices. Scape predominantly olive colored with black and cream mottling. **Thorax.** Concolorous with scape. **Wings.** Forewing length 5.1–6.5 mm. Dorsal surface of forewings base color olive with black and cream mottling and four or five ill-defined dark spots in the central wing area, two opposite cream-colored maculae distally. Fringe gray. Ventral surface of forewings uniformly brown. Dorsal surface of hindwings silvery-gray, gradually becoming darker at the distal half. Fringe cream-colored at base with

remainder gray-brown. Costal hair pencil present, dark-gray, about 0.5x length of the wing. Vannal tuft absent. Ventral surface of hindwings slightly lighter brown than ventral surface of forewings. Legs brown with cream-colored apices on each segment. **Abdomen.** Scaling gray ventrally and dorsally, cream-colored laterally. Segments II and III dark brown dorso-medially. Pleural lobes on sternite VIII semi-circular, about 0.5x length of valva (Fig. 2F). Oval sclerotization on sternite VII (Fig. 2E), right sternite hook on segment VII extending about 0.6x width of abdomen, apically spatulate. Left sternite hook present, small. **Male genitalia.** (Fig. 2C, D). Setae of various lengths along ventral edLe of distal 0.7x of valvae. Valvae asymmetrical. Left valva dorsally curved, apically triangle-shaped widening to half as wide as length; distal end with five spurs: three sharp medial spurs and, anteriorly, two, slightly longer, spatulate spurs. Right valva ventrally curved, widened into a club about 0.3x the length of the valva with five rounded spurs of roughly equal size, smaller than the spurs on the left valva. A small costal process at about 0.3x of the right valva. Anellus lobes asymmetrical. Left anellus lobe with a distinct process in the center and irregular tapering to a rounded tip; right anellus lobe narrow at base and widening into a club. Brachia asymmetrical. Right brachium elongated with several curves, tapering to a sharp point. Left brachium reduced to small bump. **Female.** Like male, except costal hair pencil absent, pleural lobes absent, and no sclerotization on sternite VII or sternite hooks. **Female genitalia** (Fig. 2B). Anterior apophyses and posterior apophyses straight and each about 1x length of segment VII. Ostium with sclerotized ring, sterigma sclerotized, externally protruding, and curled to the right. Ductus bursa about 0.5x length of oval bursa copulatrix. Signum absent.

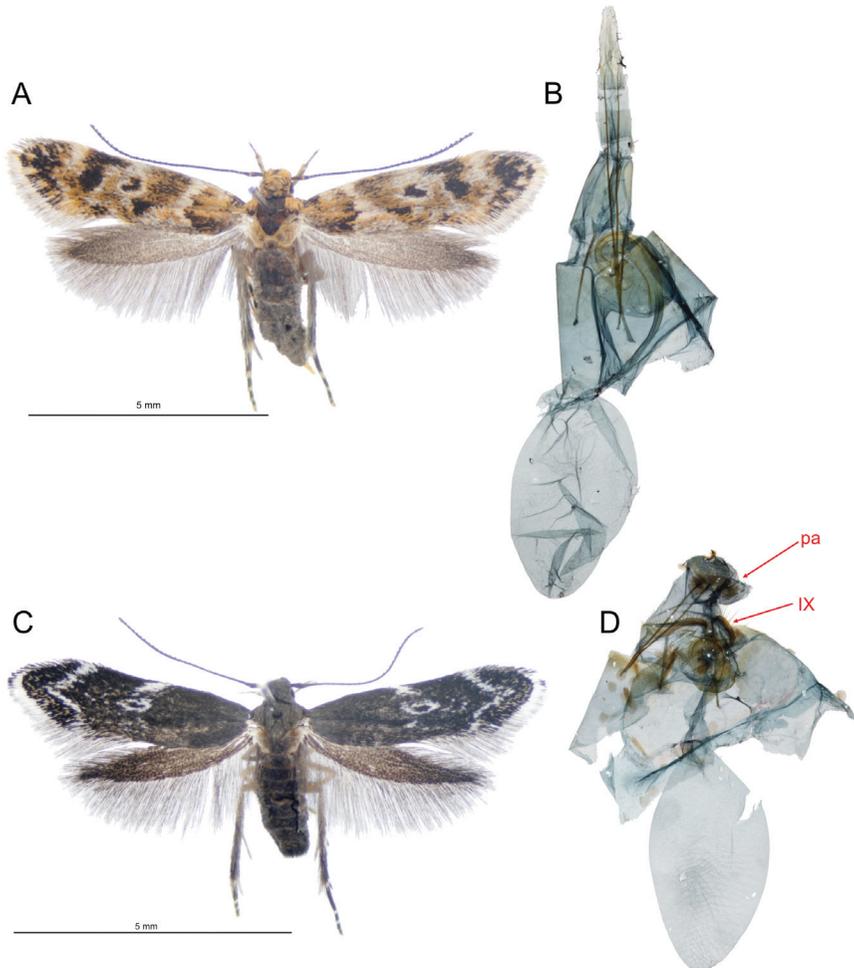


**Figure 3.** A. Paratype adult of *Hyposmocoma kukilakila* sp. n., DR21D16B.E1, DNA00228, reared from a “tiny burrito” type case from Kamehamenui FR. B. Female genitalia of same specimen, slide KAA0899. C. Male genitalia, tegumen, ventral view, paratype slide KAA0960. D. Male genitalia, valvae and aedeagus, slide KAA0960, digitally dissected partial valvae with spurs intact below, paratype slide KAA0959. E. Pleural lobes on sternite VIII, slide KAA0959. F. Sternite sclerotization and protruding sternite hook on segment VII, slide KAA0959. Abbreviations: lb = left brachium, rb = right brachium, st = sterigma, sp = spur, la = left anellus lobe, ph = phallus, ra = right anellus lobe, ss = sternite sclerotization, rsh = right sternite hook.

**Biology.** The larva make large “burrito” type cases, ~7–8 mm long at final instar (Fig. 6D). Burrito type cases have a

single opening and are either bag-shaped or taper to a point opposite of the side with the opening. The surface of the case

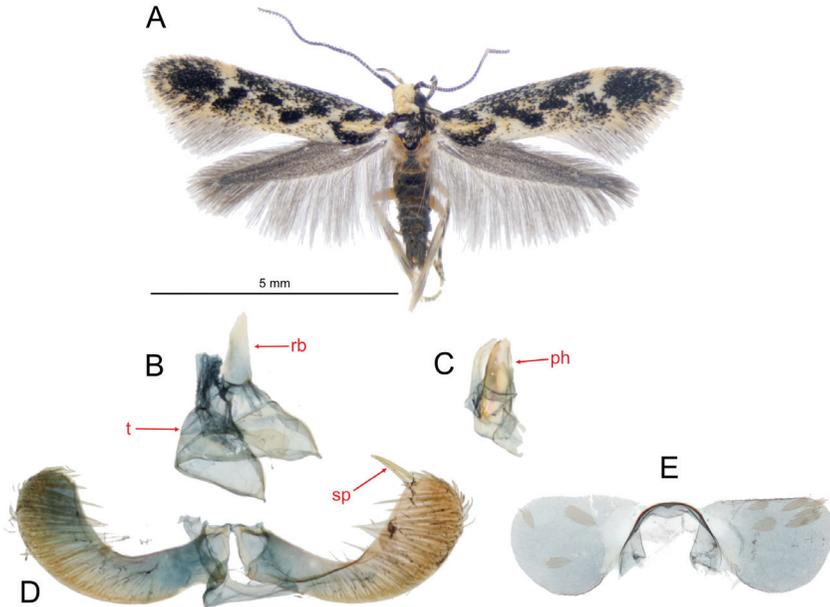




**Figure 4.** A. Holotype adult *Hyposmocoma desilvai* sp. n., DR21D16E.1, DNA00252, reared from a “cigar” type case from Kamehamenui FR. B. Female genitalia of same specimen, slide KAA0902. C. Holotype adult *H. makaohuna*, DR21D16A.E3, DNA00255, reared from a “candywrapper” type case from Kamehamenui FR. D. Female genitalia of same specimen, slide KAA0901. Abbreviations: pa = papilla anales, IX = segment IX.

becoming dark-gray distally. Fringe gray. Underside of hindwings light gray. Vannal tuft absent. Hindwing costal hairpencil absent. *Legs*. Femur and tibia of all legs cream colored, remaining segments charcoal with white colored apices of each segment. *Abdomen*. Scaling uniformly

charcoal black. Pleural lobes on sternite VIII oval (Fig. 3E). Sclerotized arc on sternite VII that extends laterally as a sternite hook 0.6x width of sternite (Fig. 3F). *Male genitalia*. (Fig. 3C, D). Setae of various lengths along ventral edge of distal 0.5x of valva. Valvae asymmetrical.



**Figure 5.** A. Holotype adult of *H. kamehamenui*, DR21D16B.E2, DNA00249, reared from a “burrito” type case from Kamehamenui FR. B. Male genitalia of same specimen, tegumen and brachia, lateral view, slide KAA0900. C. Phallus, same specimen. D. Valvae, same specimen. E. Pleural lobes, same specimen. Abbreviations: rb = right brachium, t = tegumen, sp = spur, ph = phallus.

Left valva narrower than right, with a broader part at 0.5x that forms the base for the spurs. Three spurs on the left valva of about equal length, two of which are lanceolate, the most distal spur triangular, 0.5–1x as wide as long (varies among type material). Right valva broader than the left and of about equal width throughout, holding three spurs of about 0.3x the length of the left spurs. The most distal spur widens towards the tip. Right valva with a ventrally thickened sclerotization along 0.6x of the valva. Anellus lobes asymmetrical. Left anellus lobe widens and at about 0.8x abruptly thinner to form a hook shape. Right anellus lobe thin at basal 0.5x and then slightly widens into a flattened club shape. Brachia asymmetrical. Right brachium about twice as wide

at the base as long, tapering to a point. Left brachium inconspicuous. **Female.** Like male. **Female genitalia.** (Fig. 3B). Posterior apophyses about 2.5x the length of the anterior apophyses. Ostium bursae weakly sclerotized, sterigma externally protruding, and curled to the right. Ductus bursa about equal length of oval bursa copulatrix. Signum absent.

**Biology.** The larval cases are of the “burrito” type, elongated with a single opening, approximately 4.0 mm in length at final instar (Fig. 6E). The surface is evenly covered with sand.

**Distribution.** Only known from East Maui on Haleakalā, in Kamehamenui Forest Reserve and Haleakalā National Park, from 2100 m up to the peak at 3050 m.

**Etymology.** The epithet “kukilakila”

is based on the Hawaiian *kā kilakila*, referring to Haleakalā in song and chant, and used for this species to reference the remarkably high elevation and cold dry climate where the larval cases of this species can be found; the peak parking lot on Haleakalā at 3045 m.

**Remarks.** We selected a female holotype because all available male specimens have worn wings or are not spread, and the wing pattern is diagnostic. The shape of the male genitalia and the presence of a sternite hook on segment VII suggest a close relationship of *H. kukilakila* to *H. swezeyi*, endemic to O‘ahu. There is no DNA sequence data available for *H. swezeyi*, it is only known from its type material collected in the early 20th century in the Kaimukī neighborhood of Honolulu and, considering the heavy urban development of this area, may well be extinct. The larval cases of *H. kamehamenui* and *H. kukilakila* from Kamehamenui FR are superficially similar and were initially mixed in rearing lots, but later separated based on two distinct size classes and the presence of a twist at the tip of cases of the larger *H. kamehamenui*.

***Hyposmocoma (Hyposmocoma) desilvai* sp. n.**

<https://zoobank.org/57E97161-D43B-4D24-8BDC-AC7E837A470>  
Figs. 4A, B, 6C.

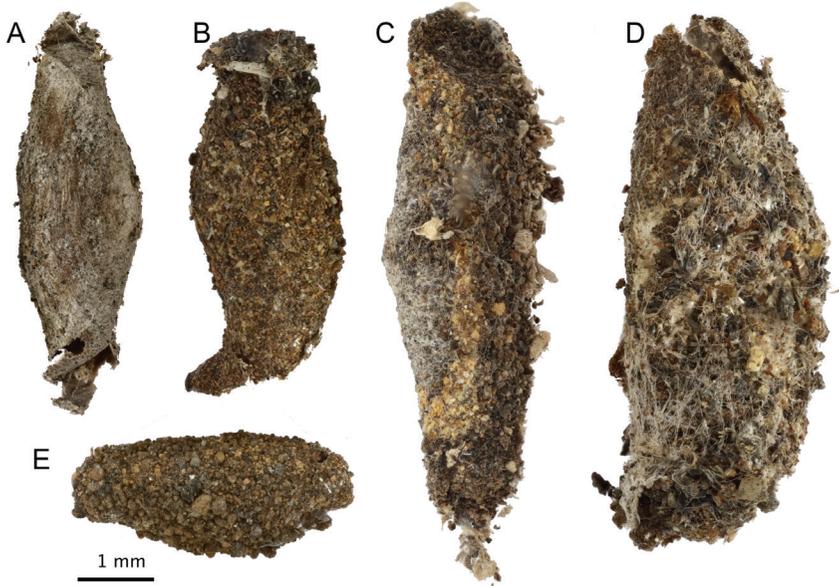
**Type material**

**Holotype.** 1 Female. USA: HI: Maui 26.iv.2021 DR21D16E.E1, Kamehamenui F[orest] R[eserve] Hand coll.[ected] Cigar case. E[x][arva] 4.vi.2021. N 20.7285 E -156.2786 2135 m. Leg.[it] F. and K. Starr. DNA extract: DNA00252. Genitalia slide: KAA0902. Deposited in UHIM.

**Diagnosis.** *Hyposmocoma desilvai* is endemic to East Maui and has an overall calico color pattern, which is similar to several other species in the carnivorous

species group, but most likely to be confused with *H. pupumoehewa* Schmitz and Rubinoff, also endemic to East Maui. *Hyposmocoma desilvai* can be differentiated by having a white fascia at 0.2x of the wing and a white-edged black spot centrally at 0.5x of the wing, whereas *H. pupumoehewa* has no clear patterning and mottling with black scales all over the forewings and thorax that obscures the calico color pattern. COI sequence data separates *H. desilvai* from all other described and sequenced species in this group, minimum pairwise distance to nearest neighbor 4.92%.

**Description. Female. Head.** Frons and vertex with orange-brown appressed scales. Anterior basal part of haustellum with cream colored scales. Labial palpus with mixed brown, white, and orange scales. Terminal two palpomeres of labial palpus of about equal length. Antenna about 0.8x length of forewing, scape dark brown with cream anteriorly, antennomeres dark brown. Live specimen with red eyes (gray in pinned specimen). **Thorax.** Dark brown, tegulae orange with dark brown tipped scales anteriorly. **Wings.** Forewing length 4.9 mm. Patch of raised scales along dorsum. Forewing coloration calico: base color orange with a white fascia at 0.2x, a white-edged black mark centrally, a white costal mark at 0.8x and 4–6 small white spots apically. Black mottling outside the white marked areas with some densely mottled areas forming spots. One spot just below the central white-outlined spot and one spot beyond it, the latter connecting to the costa. Distal edge of the wing mostly black. Forewing fringe white with dark gray tips. Underside of forewings brown. Hindwings beige-gray, tending darker apically, fringe gray. Hindwing vannal brush absent. Underside of hindwings slightly lighter brown than forewing underside. **Legs.** Light gray on inside, dark gray on outside, with cream



**Figure 6.** Larval cases of the new species, all to same scale. A. *Hypsmocoma makaohuna*, rearing lot DR21D16A, B. *H. kamehamenui*, rearing lot DR21D16B, C. *H. desilvai*, larval case of holotype (note case openings on both ends), D. *H. starrorum*, rearing lot DR21E1A (single case opening), E. *H. kukilakila*, rearing lot DR21D16B.

rings on apices of each segment and some mottling with orange scales throughout. **Abdomen.** Dark gray. **Female genitalia.** Posterior apophyses about 2x length of the anterior apophyses. Ostium bursae sclerotized, externally protruding, and curled to the right. Ductus bursa about 0.5x length of oval bursa copulatrix. Signum absent. **Male.** Unknown.

**Biology.** The larval case is a ~7.5 mm long dual-opening elongated tube (“cigar” case type), sparsely decorated with sand, and silken threads to other parts (Fig. 6C). Cigar type cases are elongated but do not widen centrally as with burrito cases, and have a case opening at each side, whereas burrito cases only have one. Prior to pupation, one end was attached to substrate with silk to suspend the case, as is typical for carnivorous *Hypsmocoma*.

**Distribution.** Only known from its type locality on East Maui in Kamehamenui FR.

**Etymology.** The species epithet, *desilvai*, is a noun in genitive case, named in honor of Lance DeSilva, who generously supported the authors and other collectors with permits and helicopter access to different forest reserves and found funds for DNA sequencing for this project, all of which led to the discovery of this remarkable species.

**Remarks.** Six larval cases were collected, but only a single female emerged. The wing pattern, red eyes, larval case type, and COI sequence data clearly place this species in the carnivorous species group of subgenus *Hypsmocoma*. The larvae of this group are strict carnivores with some species specialized to hunt native Hawaiian snails (Rubinoff and Haines 2005) and it is likely that *H. desilvai* has a similar diet, but this will need to be confirmed with future field observations.

***Hyposmocoma (Hyposmocoma)*  
*makaohuna* sp. n.**

<https://zoobank.org/94F0D59F-52CA-485D-8CF3-849C914D2145>

Figs. 4C, D, 6A.

**Type material**

**Holotype.** Female. USA: HI. Maui 26.iv.2021 DR21D16A.E3, Kamehamehenui [Forest] R[eserve] Hand coll.[ected] Candy wrapper cases. E[x][arva] 20.v.2021. N 20.7285 E -156.2786 2135 m. Leg.[it] F. and K. Starr. DNA extract: DNA00255. Genitalia slide: KAA0901. Deposited in UHIM.

**Differential diagnosis.** Endemic to East Maui. The forewing pattern with a bright white central oval ring, a white costal mark above it, and a white fascia that curves to a distal point in the center at 0.8x of the wing on an almost black forewing is unique within *Hyposmocoma*. Not similar to any described species.

**Description. Female. Head.** Frons and vertex covered with charcoal black appressed scales. Anterior basal part of haustellum with white scales. Second palpomere of labial palpus white with some brown scales apically, third palpomere black with some white scales. Third palpomere about 0.7x length of second palpomere. Antenna about 0.7x length of the forewing, scape and antennomeres black. **Thorax.** Uniformly charcoal black. **Wings.** Forewing length 3.9 mm. Forewing with a dark brown to black base color with a bright white oval ring in the center of the wing, and a bright white angled costal mark directly above it. A bright white fascia at 0.9x of the wing, that curves distally in the center. Forewing fringe white with black tips apically, gray dorsally. Forewing underside brown. Hindwings dark brown with a gradient to black at the distal half, fringe dark brown. Vannal brush absent. Hindwing underside brown. **Legs.** Black with bright white tipped apices of each

segment. **Abdomen.** Uniformly charcoal. **Female genitalia.** Papilla anales sclerotized. Posterior side of segment IX with a sclerotized bar with setae. Posterior apophyses about 2x length of anterior apophyses, 0.6x width of segment IX. Ostium sclerotized, sterigma sclerotized and externally protruding and curled to the right. Ductus bursa about 0.2x length of oval bursa copulatrix. Signum absent. **Male.** Unknown.

**Biology.** The male is unknown, but likely similar to female. The final instar larval case is elongated, dual-opening, about 5.5 mm in length, with constrictions at either end (“candywrapper” type) (Fig. 6A). Candywrapper type cases are typified by constricted sections at either end, and flaring out apically towards the openings—resembling a wrapped candy. Likely, the cases were adorned with bits of yellow or green lichen in the field as is typical of this group, but the lichen are easily lost in transport and the rearing process; only small fragments remain on the preserved cases.

**Distribution.** Only known from its type locality on East Maui in Kamehamehenui FR.

**Etymology.** The epithet “makaohuna” is a compound noun in genitive case transliterated from the Hawaiian *maka* (“eye”) and *ohuna* (“hidden”), referring to the appearance of a pair of eyes on the forewings when they are spread.

**Remarks.** Over 20 larval cases were collected, but only a single female emerged. The sclerotized papilla anales, sclerotized posterior of segments IX and X, and markedly short apophyses place this species in what has been referred to as the *H. admirationis* Walsingham group (*sensu* Zimmerman [1978]), or in more recently published work, the “candywrapper” group—referring to the shape of the larval cases. Although DNA was extracted, we have been unable to

obtain sequence data, which could further elucidate its relationship with other *Hyposmocoma*.

***Hyposmocoma (Hyposmocoma) kamehamenui* sp. n.**

<https://zoobank.org/984113DD-3F42-4F9B-923C-65EAD10A7334>  
Figs. 5, 6B.

**Type material**

**Holotype.** Male. USA: HI. Maui 26.iv.2021 DR21D16B.E2, Kamehamenui F[orest] R[eserve], Hand coll.[ected] burrito cases. E[x][arva] 26.v.2021. N 20.7285 E -156.2786 2135 m. Leg.[it] F. and K. Starr. DNA extract: DNA00249. Genitalia slide: KAA0900. Deposited in UHIM.

**Diagnosis.** *Hyposmocoma kamehamenui* is very similar to *H. moopaliikea* Schmitz and Rubinoff, also found on East Maui, but *H. kamehamenui* can be distinguished by having a clearly defined crescent-shaped black mark on the forewing vannal area, which is yellow/white mottled with gray and black in *H. moopaliikea* without any distinct shapes. In addition, the head is entirely bright yellow, which usually has darker central scales in *H. moopaliikea*. In the male genitalia, the right brachium is about 2x long as it is wide in *H. kamehamenui*, and about 3x long as it is wide in *H. moopaliikea*. COI sequence data separates *H. kamehamenui* from all other described and sequenced species in this group, minimum pairwise distance to nearest neighbor 7.95%.

**Description.** *Male.* (Fig. 5A). *Head.* Frons and vertex covered with light yellow appressed scales. Anterior basal part of haustellum with white scales. Labial palpus with light yellow and black scales interspersed, third palpomere 0.6x length of second palpomere. Antenna about 0.9x length of forewing. Scape black, white at the tip. Antennomeres black with white apices. *Thorax.* Mostly black with some

yellow mottling. *Wings.* Forewing length 4.7 mm. Ground color white to bright yellow, with black mottling throughout. Five ill-defined dark spots in the central wing area, distal 0.2x of the wing black, with small bright yellow spots along the wing apex. A crescent-shaped black spot in the vannal area. Forewing underside brown. Hindwings silvery-gray, fringe gray. Hindwing costal brush absent. Vannal brush absent. Hindwing underside gray. *Legs.* Yellow with black laterally. Bright yellow apices on each segment. *Abdomen.* Dark gray. Sternite sclerotization or sternite hooks on segment VII absent. Pleural lobes semi-circular (Fig. 5E). **Male genitalia.** (Fig. 5B, C, D). Setae of various lengths along ventral edge of 0.7x of valva. Valvae symmetrical, curved dorsally, slightly widening posteriorly, with a smoothly rounded apex. Two spurs of equal size on the right valva, left two spurs on genitalia of holotype slide missing, but sockets visible. Anellus lobes absent. Right brachium tapering to a point, about 2x long as wide. **Female.** Unknown.

**Biology.** The final instar larval “burrito” case is ~5.0 mm long with a single opening, tapering at the opposite end with a twist at the tip (Fig. 6B). The surface of the case is evenly covered with sand and moss particles.

**Distribution.** Only known from its type locality on East Maui: Kamehamenui FR.

**Etymology.** The epithet “kamehamenui” is a toponym noun in genitive case, referencing the type locality; Kamehamenui Forest Reserve in the Kamehamenui *ahupua’a* (subdivision) of East Maui.

**Remarks.** Five larval cases were collected. *Hyposmocoma moopaliikea* is an aquatic species, its larvae were found in Palikea stream in Haleakalā National Park. We here present additional records from East Maui, in Makawao Forest Reserve and Hanamu Gulch, near Olinda

(dx.doi.org/10.5883/DS-5MAUIHYP). Although *H. moopalikea* and *H. kamehamenui* have a close geographic affinity, and highly similar external morphology and male genitalia, the DNA results and habitat suggest they are not sister species (Fig. 6). Based on COI sequence in our dataset, *H. kamehamenui* comes out closest to *H. aumakuawai* Schmitz and Rubinoff, an aquatic species endemic to Kaua'i, but it is likely that there are other unsampled species that are more closely related. The larval cases of *H. kamehamenui* and *H. kukilakila* from Kamehamenui FR were initially mixed in rearing lots because the smaller cases look very similar and they were collected from the same places, but later separated based on two distinct size classes and the presence of a twist at the tip of cases of *H. kamehamenui*.

### Discussion

The fact that we are only describing five new species here should not be mistaken for the reaching of an asymptote of the discovered and described diversity of *Hyposmocoma*. From unpublished data and collections, we know of dozens or perhaps hundreds of undescribed species across the Hawaiian Islands. However, it is highly difficult to reconcile new collections with previously established species names due to the difficulty of accessing type material retained in foreign collections. As we continue to build contemporary *Hyposmocoma* collections in Hawai'i—including DNA data—we expect to discover and describe many more species in the coming years. Even from a rather degraded habitat like Kamehamenui FR, several other species of *Hyposmocoma* were collected for which we have not yet been able to ascertain if they are described species. Thus, other new species likely await description but require access to types or images that are not available.

The newly described species exemplify

the importance of establishing and restoring forest reserves for conservation. This is especially true for degraded areas adjacent to longer established forest reserves that have potential for habitat expansion if native understories are restored. It is likely that a similar fauna to that present in Kamehamenui Forest Reserve is also present in the neighboring Kula Forest Reserve, but the latter has not been the focus of any recent insect surveys for *Hyposmocoma*. Finally, the study of *Hyposmocoma* is not only important for conservation purposes, but it is also the most ecologically diverse radiation of insects in Hawai'i and gives a unique perspective on the global evolutionary mechanisms involved in generating adaptive radiations. Continued discoveries of new species and relationships in *Hyposmocoma* is certain, as long as there is support from land managers and biologists willing to make the effort to find them.

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