

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 103, NUMBER 1

DISTRIBUTION AND VARIATION OF THE
HAWAIIAN TREE SNAIL *ACHATINELLA*
APEXFULVA DIXON IN THE
KOOLAU RANGE, OAHU

(WITH 12 PLATES)

BY

D'ALTÉ A. WELGH



(PUBLICATION 3684)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
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INTRODUCTION

SCOPE OF WORK

In a previous paper (Welch, 1938) the species *Achatinella mustelina* is studied. The present paper continues the work on Hawaiian tree snails and deals with the species *Achatinella apexfulva*, also of the island of Oahu. Does the same variation or series of variations occur

in *A. apexfulva* of the Koolau Range as in *A. mustelina* of the Waianae Mountains?

During the 7 years I spent in Hawaii studying *Achatinella* I was greatly helped in acquiring a background for the present work by Dr. C. M. Cooke, Jr. Working under Dr. Cooke, I also learned many methods of studying and preparing material which greatly facilitated my work. I am also indebted to Dr. E. A. Andrews, Dr. Henry A. Pilsbry, Dr. H. B. Baker, and Dr. Ernst Mayr for criticisms and advice in the preparation of the manuscript. Dr. F. Raymond Fosberg was most helpful in identifying all genera of Hawaiian plant names given by various collectors of shells. I also wish to express appreciation to the following for various courtesies and favors: Dr. Paul Bartsch, W. J. Clench, W. T. Calman, Col. A. J. Peile, J. R. le B. Tomlin, G. S. Robson, Dr. Paul Galstoff, Dr. Gilbert D. Harris, Dr. C. E. McClung, Dr. Peter H. Buck, Dr. Herbert Gregory, the Trustees of the Bernice P. Bishop Museum, and the authorities of the United States National Museum.

The ground work of this paper was done at the Bernice P. Bishop Museum in Honolulu, the writing of the paper was carried on at the United States Bureau of Fisheries at Woods Hole, the Zoological Laboratory of the University of Pennsylvania, the Zoological Department of the Johns Hopkins University, and the Zoological Department of Barat College, Lake Forest, Ill. I wish to thank these institutions for granting me facilities for work.

PLACE NAMES OF THE KOOLAU RANGE

Most of the names of the valleys or gulches of the Koolau Range are well known, but the names of some have never appeared on a Government map. Other gulch names have not been known, and still other gulches, although their names are well known, contain large subgulches that need to be designated by some name in order that localities may be described exactly.

Pilsbry and Cooke (1912-1914, p. 277) published a rough diagrammatic sketch map of the northwestern half of the Koolau Range in which they included the new names Kalaikoa, Ahonui, Main Poamoho, Central Poamoho, West Poamoho, Kawaihalona, and Luapo. This map was compiled from field notes made by Irwin Spalding and is the first published map showing the approximate regions occupied by colonies of *Achatinella*. Many of these names do not exist on the advance sheets of the United States Geological Survey topographic sheets of Oahu, Hawaiian Islands, 1/20,000, which form the standard map I used for plotting all localities of

Achatinella and from which all maps published in this paper have been compiled. Therefore a considerable amount of work has been done to check the place names on the Pilsbry-Cooke map and to ascertain the place names of all valleys not yet published.

I am indebted to the following people for help in this work: The Bishop Estate for access to maps, Miss Jane L. Winne for place

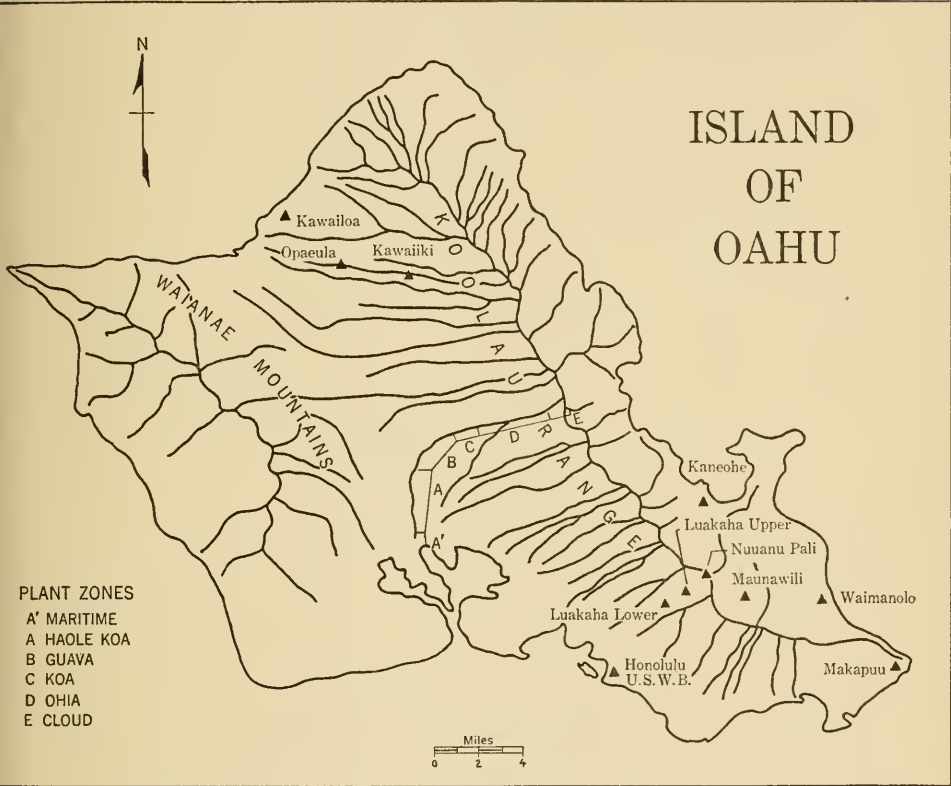


FIG. 1.—Island of Oahu, showing the plant zones in Kipapa Gulch (after Hosaka) and the location of rain-gage stations in the Koolau Range. Ridges outlined in solid lines.

names obtained from an old Hawaiian native to the district of Maunaloa; Manuel Baptista, a former cattle ranger native to the districts of Kalauao and Waiawa; G. D. Robinson; William Holt, a former cattle ranger in the regions of Wahiawa and Paala; Benny Pulaa, a Hawaiian native to the districts of Kawaiiloa, Waimea, and the northern section of Oahu.

The Koolau Range is divided into six large land grants or districts which are numbered A to F on figure 2, p. 4. Within these large

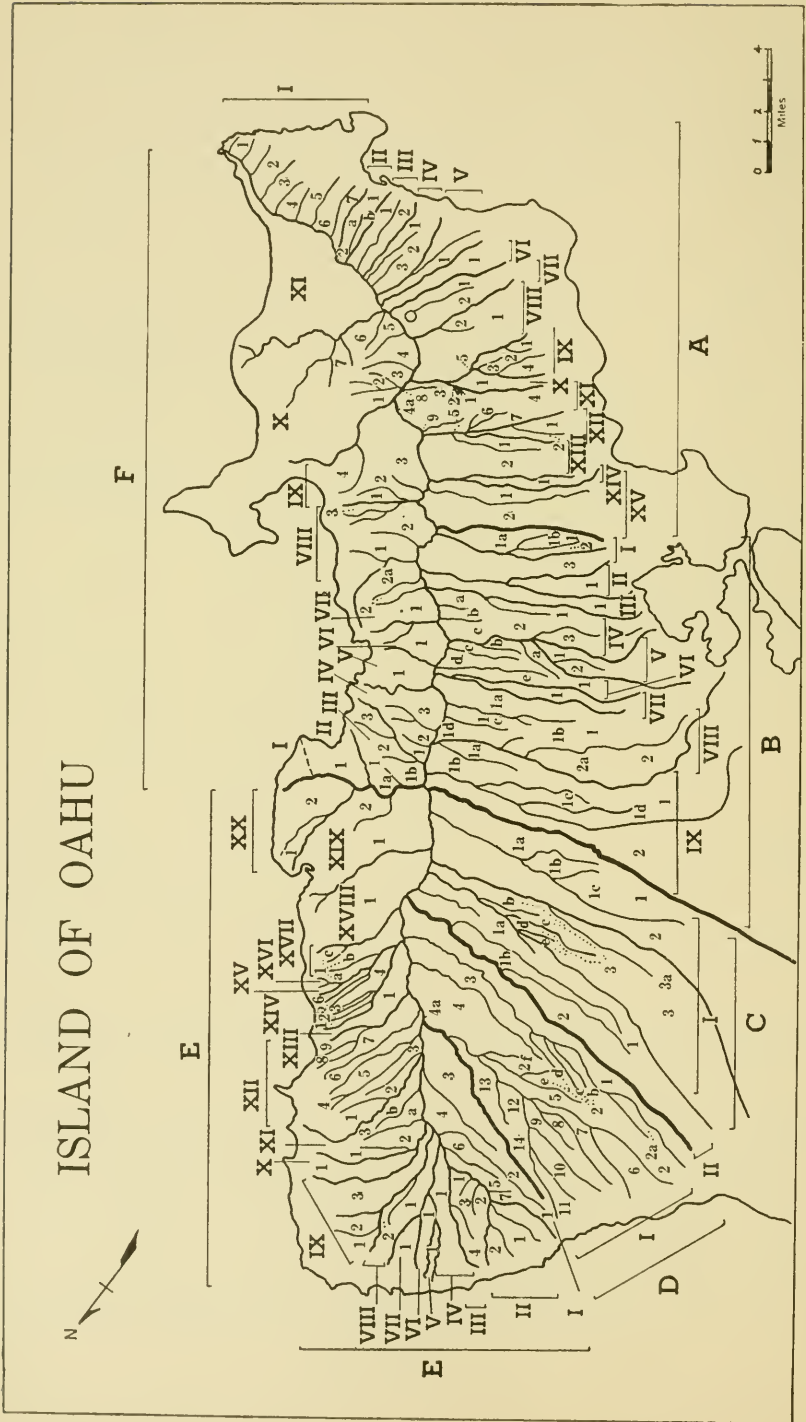


Fig. 2.—Key map of the place names of the Koolau Range. Ridges outlined in black.

districts are smaller districts or subdistricts indicated by Roman numerals, which may include a single valley or gulch with the same name or several valleys with different names. The valleys or gulches within a subdistrict are numbered in Arabic. In the discussion of place names, all names not published on the United States Geological Survey topographic advance sheets of the island of Oahu will have in parentheses the names of the authorities after them. Main valleys or gulches are often subdivided by the author for convenience into north, south, east, west, or central. These main valley subdivisions may be broken up again into north or south branches.

Figures 1 and 3-6 were drawn by Gordon Brett Littlepage from maps compiled by me. Figures 2, 7, 8 were drawn by me. All maps are compiled from the United States Geological Survey topographic advance sheets of the island of Oahu. Ridges on all maps are represented by lines.

Place names of the Koolau Range

A. Honolulu District.

I. Maunalua.

- 1, Kealakipapa Valley; 2, Mauuwaii Valley; 3, Kalama Valley; 4, Kamiloiki Valley; 5, Kamilonui Valley; 6, Hahaione Valley; 7, Kaalakei Valley (Bishop Estate maps: J. Winne).

II. Kuliouou.

- 1, Kuliouou Gulch; 1a, East Branch (Welch); 1b, West Branch (Welch); 2, Puu O Kona.

III. Niu.

- 1, East Niu Gulch; 2, West Niu Gulch. (1-2 Welch.)

IV. Wailupe.

- 1, Kului Gulch; 2, Lauilaupoe Gulch; 3, Wailupe Gulch.

V. Waialae Iki.

- 1, Kapakahi Gulch (in this paper Waialae Iki Gulch will be used in preference to Kapakahi Gulch).

VI. Waialae Nui.

- 1, Waialae Nui Gulch (spelled Waialaenui on U. S. Geol. Surv. topogr. advance sheets).

VII. Palolo.

- 1, Waiomao Stream; 2, Pukele Stream.

VIII. Manoa.

- 1, Manoa Stream; 2, East Manoa Stream (Welch).

IX. Makiki. (This name is not on the U. S. Geol. Surv. topogr. advance sheets, but it is a well-known name and has been in use by shell collectors for many years.)

- 1, Maunalaha Stream; 2, Moleka Stream; 3, Kanealole Stream; 4, Kanaha Stream; 5, Puu Ohia (Tantalus).

X. Pauoa.

- 1, Pauoa Valley.

XI. Nuuanu.

- 1, Glen Ada; 2, Glen Elm; 3, Lulumahu Valley; 4, Nuuanu Stream; 4a, Nuuanu Pali; 5, Hillerbrand's Glen; 6, Maole Stream; 7, Waio-lani Stream (Rook's Valley, Cooke); 8, Puu Konahuanui; 9, Puu Lanihuli. (1-3, 5, place names given by Dr. Cooke to certain unnamed places where shells were collected.)

XII. Kapalama.

- 1, Niuhelewai Stream; 2, Kapalama Stream.

XIII. Kalihi.

- 1, Kamanaiki Stream; 2, Kalihi Stream.

XIV. Kahauiki.

- 1, Kahauiki Stream.

XV. Moanalua.

- 1, Manaiki Stream; 2, Moanalua Stream.

B. Ewa District.

I. Halawa.

- 1, South Halawa Stream; 1a, South Branch (Welch); 1b, North Branch (Welch); 2, Central Halawa Stream (Welch); 3, North Halawa Stream.

II. Aiea.

- 1, Aiea Stream.

III. Kalauao.

- 1, Kalauao Stream.

IV. Waimalu.

- 1, Hanaiki Stream (Bishop Estate maps); 2, Waimalu Stream; 2a, South Branch; 2b, Central Branch; 2c, North Branch; 3, Punanani Gulch. (2a-2c Welch.)

V. Waiau.

- 1, South Waiau Gulch; 2, North Waiau Gulch. (1-2 Welch.)

VI. Waimano.

- 1, Waimano Stream; 1a, South Waimano Stream; 1b, South Central Waimano Stream; 1c, Central Waimano Stream; 1d, North Central Waimano Stream; 1e, North Waimano Stream. (1a-1e Welch.) 1a-1c are in the district of Waiau but for convenience have been considered part of the Waimano Stream system.

VII. Manana.

- 1, Manana Stream.

VIII. Waiawa.

- 1, Waiawa Stream; 1a, South Waiawa Stream (Welch); 1b, North Waiawa Stream (Welch); 1c, North Waiawa Stream, South Branch (Welch); 1d, North Waiawa Stream, North Branch (Welch); 2, Panakauahi Gulch; 2a, Panihakea Gulch (Baptista), the upper part of Panakauahi Gulch. (Mr. Baptista tells me that the Hawaiian name for South Waiawa Stream is Keahupuolo Stream. However the shells in the collection are labeled South Waiawa and I think it is advisable to use this name in preference to Keahupuolo.)

IX. Waipio.

- 1, Kipapa Gulch; 1a, South Kipapa Gulch; 1b, Central Kipapa Gulch; 1c, North Kipapa Gulch, second North Branch; 1d, North Kipapa Gulch, first North Branch. (G. D. Robinson tells me that only the lower portion of the valley should be called Kipapa Gulch. The upper portion is Waipio Valley. Kipapa was the crossing place in the gulch where stones were placed together to form a road. A. F. Judd also considers Waipio to be the correct name of the Gulch. However, since the collections and the U. S. Geol. Surv. topogr. advance sheets use the name Kipapa, I believe it would be confusing to use Waipio.); 2, Waikakalaua Stream. (1a-1d Welch.)

C. Wahiawa District.

I. Waianae Uka.

- 1, South Kaukonahua Stream; 1a, South Kaukonahua, South Branch (Welch) (this may be Gulick's Kalaikoa District, or Kalaikoa may have included all of South Kaukonahua Stream); 1b, South Kaukonahua, Central Branch (Welch); 1c, South Kaukonahua, North Branch (Welch); 2, North Kaukonahua Stream. (Mr. Robinson showed me a place where formerly stood a boulder called Oahunui. The saying was that if anybody walked around this rock in a spiral starting at the bottom and going up to the top he would have gone around the island of Oahu. Ahonui may be a corruption of the word Oahunui. The place shown me is in the South Kaukonahua at an elevation of about 900 feet, below or opposite the North Branch of the South Kaukonahua. Pilsbry and Cooke, on the authority of Spalding, who in turn probably obtained accurate information from J. S. Emerson, an authority on Hawaiian place names, places Kalaikoa and Ahonui of Gulick between the North and South Kaukinehua (a misspelling for Kaukonahua), Kalaikoa being in the Central Branch, and Ahonui in the North Branch, of the South Kaukonahua. This ties in with Mr. Robinson's information. Ahonui of Gulick, however, may have included this region as well as North Kaukonahua Gulch. The Gulick shells represent a mixture from over a considerable area.); 3, Poamoho Stream; 3a, South Poamoho Stream; 3b, Central Poamoho Stream (Main Poamoho, Pilsbry and Cooke); 3c, Central Poamoho Stream, North Branch; 3d, North Poamoho Stream (Central Poamoho?, Pilsbry and Cooke); 3e, North Poamoho Stream, North Branch (West Poamoho, Pilsbry and Cooke). (3a-3e Welch.)

II. Paala Uka.

- 1, Helemano Stream; 1a, South Helemano Stream (Welch); 1b, North Helemano Stream (Welch); 2, Kawaihalona Gulch (Holt, Robinson, Pulaa, Pilsbry and Cooke).

D. Waiialua District.

I. Kawailoa.

- 1, Opaaula Gulch; 2, Kawailoa Gulch; 2a, First South Branch; 2b, Second South Branch; 2c, Third South Branch; 2d, Fourth South Branch; 2e, First North Branch; 2f, Second North Branch (2a-2f Welch); 3, Kawaiiki Gulch; 4, Kawainui Gulch; 4a, Puu Kainapuaa; 5, Kawaiipapa Gulch (Pulaa) (this Gulch will always be

referred to as Kawaiipapa, Kawailoa Gulch, because this place name occurs elsewhere in the Koolau Range); 6, Ukoa Gulch; 7, Kukaiohiki Gulch; 8, Keamanea Gulch; 9, Kaluapo Gulch (Luapo, Pilsbry and Cooke); 10, Kaalaea Gulch; 11, Kaluahole Gulch; 12, Waoala Gulch (wrongly spelled Waiola on the U. S. Geol. Surv. topogr. advance sheets); 13, Huluela Gulch; 14, Kawaiiole Stream. (5-13 Pulaa.)

E. Koolauloa District.

I. Waimea.

1, Waimea River; 2, Kamananui Stream; 3, Kolokini Stream (Pulaa); 4, Namahana Stream (Pulaa); 5, Elehaha Stream; 6, Kawaieli Stream (Pulaa). (Mr. Pulaa tells me that the Kawaieli Stream is where the Elehaha Stream is marked on the map. However, for convenience I shall not change the position of the Elehaha Stream on the U. S. Geol. Surv. map but shall consider the stream to the south the Kawaieli Stream instead of the Elehaha.); 7, Kauwalu Stream.

II. Pupukea.

1, Kalunawaikaala Stream; 2, Pakulena Stream.

III. Paumalu.

1, Paumalu Stream; 2, Kaleleiki Stream; 3, Kawaiipi Stream; 4, Aimu Stream.

IV. Kaunala.

1, Kaunala Gulch.

V. Waialea.

1, Waialea Gulch.

VI. Pahipahialua.

1, Pahipahialua Gulch.

VII. Opana.

1, Kawela Gulch.

VIII. Hanakaoe.

1, Oio Stream; 2, East Oio Stream.

IX. Kahuku.

1, Hoolapa Gulch; 2, Kalaeokahipa Gulch; 3, Ohia ai Gulch.

X. Keana.

1, Keaaulu Gulch.

XI. Malaekahana.

1, Lamalao Gulch; 2, Hiina Gulch; 3, Malaekahana Stream; 3a, North Malaekahana Stream; 3b, South Malaekahana Stream. (3a-3b Welch.)

XII. Laie.

1, Omao Gulch; 2, Kaluakauila Gulch; 3, Kahawainui Gulch; 4, Kaaoao Gulch; 5, Ihihi Gulch; 6, Waiicle Gulch; 7, Koloa Gulch; 8, Aakaki Gulch; 9, Kokolofio Gulch.

XIII. Kaipapau.

1, Kaipapau Gulch.

XIV. Hauula.

1, Waipilopilo Gulch; 2, Hanaimoa Gulch; 3, Kawaiipapa Gulch; 4, Maakua Gulch; 5, Papali Gulch; 6, Punaiki Gulch.

XV. Makao.

XVI. Kapaka.

XVII. Kaluanui.

1, Kaluanui Stream; 1a, North Kaluanui Stream; 1b, Central Kaluanui Stream; 1c, South Kaluanui Stream. (1a-1c Welch.)

XVIII. Punaluu.

1, Punaluu Stream.

XIX. Kahana.

1, Kahana Stream; 2, Kawa Stream.

XX. Kaaawa.

1, Olona Gulch (Meinecke), or Weliweli Gulch (Oswald). (I am using the name Olona because I have heard from some source other than Meinecke that that was the correct name, and I have heard of Weliweli from only one source. However, I am not at all sure which is correct.); 2, Kaaawa Stream.

F. Koolaupoko District.

I. Kualoa.

II. Hakipuu.

1, Hakipuu Stream.

III. Waikane.

1, Waikane Stream; 1a, North Branch; 1b, South Branch; 2, Waikane Stream; 3, South Waikane Stream (Welch).

IV. Waiahole.

1, Uwau Stream; 2, Waianu Stream; 3, Waiahole Stream.

V. Kaalaea.

1, Kaalaea Stream.

VI. Waihee.

1, Waihee Stream.

VII. Kahaluu.

1, Kahaluu Stream; 2, Ahuimanu Stream; 2a, East Ahuimanu Stream (Welch).

VIII. Heeia.

1, Iolikaa Valley; 2, Haiku Valley; 3, Keahala Stream.

IX. Kaneohe.

1, Kaneohe Stream; 2, Luluku Stream; 3, Kamooalii Stream; 4, Kawa Stream.

X. Kailua.

1, Kahanaiki Stream; 2, Palapu Stream; 3, Omao Stream; 4, Maunawili Stream; 5, Aionni Stream; 6, Makawao Stream; 7, Olomana Stream.

XI. Waimanolo.

CLIMATOLOGICAL DATA AND PHYSIOGRAPHY

The main division ridge or backbone ridge of the Koolau Range extends for 37 miles along a northwest and a southeast axis in the eastern portion of the island of Oahu. Parallel to it are the Waianae Mountains, which are of smaller extent and lie in the western part of the island. The windward slope of the Koolau Range is made up of high cliffs and short ridges usually less than 3 or 4 miles long.

The leeward slope for the most part has long fingerlike ridges which may be as much as 15 miles in length and is much drier than the windward slope. The trade winds blow from the northeast and hit the high wall of cliffs on the windward slope. The maximum rainfall resulting from the rising of the moisture-laden trade winds over the mountain wall falls not on the crest of the range but leeward of the summit. This is shown in table 1, where a series of precipitation records obtained from a station at Nuuanu Pali, at the summit of the Koolau Range, shows a lower rainfall than at Luakaha, below the summit of the range. At a still lower elevation the rainfall drops considerably at the Honolulu United States Weather Bureau station. Table 1 also shows a greater precipitation at stations on the windward

TABLE 1.—*Annual precipitation records in the Koolau Range*

Station	Elevation in feet	Precipitation in inches		
		1916	1917	1918
Kaneohe	100	58.92		97.37
Maunawili	250	93.58	85.53	122.17
Waimanolo	25	55.80	63.19	66.90
Nuuanu Pali	1,136	123.30	119.00	136.00
Luakaha (upper)	1,028	196.99	159.19	202.61
Luakaha (lower)	881	175.50	146.07	187.88
Honolulu (U. S. Weather Bur.).....	111	44.96	46.64	37.46
Makapuu	570	37.97	51.44	46.64
Kawaiiki	1,185	121.94	105.08	107.32
Opauala	1,100	80.46	74.55	81.83
Kawailoa	185		38.31	46.90

side of the island, such as Kaneohe and Waimanolo, than at the Honolulu station on the leeward side. Table 1 was compiled from "Climatological Data," published by the United States Department of Agriculture.

Hosaka (1937) gives some interesting data on temperature, relative humidity, soil moisture, and soil temperature in Kipapa Gulch, which is in about the center of the Koolau Range. The general trend is a decrease in temperature and an increase in humidity with increase in elevation. The average annual rainfall taken over a period of 5 to 36 years in Kipapa Gulch is as follows: At 59.05 to 196.85 feet (Haole Koa zone), 23.07 to 24.33 inches; at 377.28 feet (Haole Koa zone) to 672.54 feet (Guava zone), 47.77 to 47.49 inches; at 738.16 feet (Koa zone), 79.05 inches; at 1,797.82 feet (Ohia zone), 199.01 inches. The atmospheric temperature records from March 19 to November 26, 1933, show an average temperature at 246.06 feet

(Haole Koa zone) of 84.56° Fahrenheit; at 738.16 feet (Guava zone), 77°; at 1,000.61 feet (Koa zone), 75°2; at 1,591.2 feet (Ohia zone), 71°6; at 2,198.2 feet (Cloud zone), 70°7 (see below for explanation of plant zones, and fig. 1, p. 3).

The extreme southeastern section of the Koolau Range is exceedingly dry (see table 1, Makapuu). The main division ridge rises toward the west to 2,200 feet above Kuliouou Gulch, at Puu O Kona (fig. 7, p. 194). Between Puu O Kona and Konahuanui the backbone ridge fluctuates in height from 2,200 to 2,600 feet. At the head of Nuuanu Valley the division ridge rises to 3,105 feet at the high peak of Konahuanui, descends at Nuuanu Pali to 1,186 feet, and rises again to 2,700 feet at Puu Lanihuli. To the northeast of Puu Lanihuli the backbone ridge fluctuates in height from 2,250 to 2,800 feet. The usual elevation would be roughly 2,400 to 2,500 feet. Above Kawainui Gulch in Kawailoa the backbone ridge begins to drop in elevation near Puu Kainapuaa. From Puu Kainapuaa to the head of Ohia ai Gulch there is a gradual descent from 2,250 to 1,750 feet. From Ohia ai Gulch to the head of Pupukea the drop is a gradual one from 1,750 to 900 feet.

Achatinella apexfulva today occurs almost exclusively on the leeward slope of the Koolau Range. The material in this paper comes from 45 ridges and 11 valleys. Five of the ridges are on the windward slope of the Koolau Range. The upper limit at which *A. apexfulva* occurs is usually from $\frac{1}{2}$ mile to $1\frac{1}{2}$ miles from the backbone ridge, but it may be farther on some ridges which have not been collected at higher elevations. The lower edge of the collectable area varies northwest of Nuuanu Valley to Kawailoa (fig. 7) from $2\frac{1}{2}$ to $5\frac{3}{4}$ miles in a straight line from the backbone ridge. In Nuuanu Valley and on the Niu-Wailupe Ridge the localities are less than a quarter of a mile from the summit of the backbone ridge. These two regions are exceptions to the general rule. It is strange that this species is not found on the backbone ridge as are other species. But as far as the material from carefully plotted localities is concerned no specimens are from the backbone ridge.

Hosaka (1937, pp. 179-180), in discussing the ecology of Kipapa Gulch distinguishes six plant zones, which are copied on figure 1. They are as follows: Maritime zone, Haole Koa zone, Guava zone, Koa zone, Ohia zone, and the Cloud zone. Hosaka writes:

In the Guava Zone *Psidium Guayava* and *Lantana Camara* are most common. Above this region is the Koa Zone, dominated by *Acacia Koa* and *Gleichenia linearis* on the slopes, and by *Aleurites moluccana* in the gully bottoms. The central portion of the native forest, the Ohia Zone, is dominated by *Metrosideros*

collina (Ohia lehua), a tree towering 15 meters or more above the ground. The cloud zone is characterized by low, dwarfed shrubs in more sheltered parts and by mat-forming *Panicum*, *Paspalum*, *Isachne*, and mosses in exposed windswept areas.

The maritime, Haole Koa, and Guava zones are mostly made up of introduced plants, according to Hosaka; the Ohia and Cloud zones contain the largest number of endemic species. The Ohia zone has the largest number of indigenous plants.

Achatinella apcxfulva is almost entirely confined to the Ohia zone and the upper portion of the Koa zone. The width of the Ohia zone obviously varies in different parts of the range. In the Nuuanu Valley region the Ohia zone is comparatively narrow; to the west, near the Poamoho Stream, it is undoubtedly wider than at Kipapa Gulch.

MATERIAL AND METHODS

Over 11,302 shells were studied, the majority of which are from 287 localities. Out of this number 6,707 adult shells were measured from lots containing 5 or more shells and having a length range of at least 3 length classes. The total number of adults from plotted localities is 3,687, of which all but 283 were collected by W. Meinecke. Mr. Meinecke is the first person to make a large collection of *Achatinella* from the Koolau Range with the localities plotted on a good map such as the United States Geological Survey topographic advance sheets of the map of Oahu. All his localities prior to 1933 were plotted from memory; after that date, up to 1937, he again collected many of his former localities and many new ones, so that many errors made in plotting from memory are checked and corrected. Mr. Meinecke is such an unusually careful worker, with such an extraordinary ability to work with maps, that I have the greatest confidence in the exact plotting of his localities. This opinion is further strengthened by a check of some of his localities, all of which were found to be correctly plotted. A few of his localities collected before July 1932 are not dependable—in fact, this comment applies to all localities collected by anyone prior to 1932, with the exception of the localities of Dr. C. M. Cooke, Jr., in Nuuanu Valley which were mapped by sketch maps made in the field.

Other collectors who have supplied shells with locality data plotted on the United States Geological Survey topographic advance sheets and collected since 1932 are G. W. Russ, H. Lemke, and H. Lemke, Jr.

From localities that are not plotted on any map come 3,002 adult shells; they are mostly localized from the Meinecke and other care-

fully collected material. The exact locality of 350 of these, mostly extinct shells from the Gulick collection in the Bishop Museum, is unknown. The remainder of the shells were collected by W. D. Wilder, O. H. Emerson, J. S. Emerson, L. A. Thurston, C. M. Cooke, Jr., R. A. Cooke, C. H. Cooke, D. D. Baldwin, E. D. Baldwin, E. Lyman, A. F. Judd, and I. Spalding.

Type specimens of all previously described forms were studied whenever possible. Those in the British Museum were photographed by E. J. Manley, those in the Academy of Natural Sciences of Philadelphia by Miss Helen Winchester, those in the Museum of Comparative Zoology by the museum photographer, and those in the Bishop Museum by Kenneth Emory. The remaining shells and the holotypes of all new subspecies figured in this paper were photographed by E. Bafford, of Baltimore, and myself.

The type of *A. swiftii* Newcomb and *A. apexfulva* Dixon were among the few types not obtained for study. The type of *A. a. swiftii* should be in the British Museum but could not be located. Possibly if search were made again it would be found labeled *A. a. turgida*. The lot labeled *A. a. swiftii* is not the type lot.

The data concerning localities are of four types. All localities that were plotted from memory or prior to 1932 have an asterisk (*) after the locality number. If the locality was collected after 1932, or if an old locality prior to 1932 has been again collected and proved correct, the locality number alone is given. A question mark (?) after the locality number indicates that there is some doubt in my mind as to the correct plotting of the material or that the material has been localized from another collector's material. All localities known only as to approximate regions and plotted years after collecting also have one question mark. Two question marks (??) after a locality or area indicate that the locality is believed to be somewhere in the approximate region, but there is no data to substantiate the plotting. The plotting of the locality may be based on the form and color pattern of the shell and what is known of shell variation in adjacent localities.

As a general rule the greatest dimension of a locality collected after 1932 is not over 100 or 200 yards, but some localities collected prior to, and even some after, this date reach an extent of a quarter of a mile or even as much as a mile. An attempt has been made to plot on the locality maps (figs. 3-6) the exact location and extent of each locality. Therefore the size of a locality and the distance between localities can be estimated from the scale of miles on each map.

Through necessity the circles denoting localities are drawn larger than the actual scale size of the localities in order that they may be seen.

All shells collected prior to 1932 were live shells. After 1932 the lots contained live and dead shells. The majority of shells measured were live specimens.

In the list of localities found with each subspecies, all lots containing less than five adult specimens have the number of dextral and sinistral specimens enumerated. If the number of adults in a lot is five or more, the number of dextrals and sinistrals, the length range, and the mean length of the shell are given in table 2, p. 15. All locality place names in the text are put in boldface type. In the Gulick lots only the type locality or localities which probably contained the subspecies are put in boldface type. Other localities which I consider doubtful are put in ordinary type.

When material is quoted under each form, the catalog numbers of the lot are quoted only when necessary. Most of the Meinecke, Russ, Cooke, and Lemke material has locality numbers, and is sufficiently distinct so as not to require the quotation of catalog numbers. All lots labeled Cooke, stand for Dr. C. M. Cooke. All lots not having locality numbers have catalog numbers given. The Gulick lots have no catalog numbers given because the Gulick lots have been selected from lots containing a mixture of color forms or subspecies and are not yet recataloged. However, the catalog numbers of the figured shells are given in the explanation of plates.

Methods of collecting material and recording localities on map tracings taken from the United States Geological Survey topographic advance sheets, the manner in which the shells are graded into length groups (table 2, p. 15), and the selecting of the typical or usual form of the shell are the same as those already described for *A. mustelina* (Welch, 1938). The only addition that should be made is the method of counting the number of whorls, which is the same as that described by Pilsbry (1939, p. xi). All holotypes of new subspecies have the usual form and color pattern of the shell unless otherwise stated.

All grading of shells into length groups for table 2, page 15, was done by two W. P. A. workers. Many of the lots were remeasured by me and found to be correct. Since the shells are all graded by the measuring rod described for *A. mustelina* (Welch, 1938, p. 12), I think there is little chance of error as far as has been ascertained from remeasuring lots here and there at random.

The following abbreviations are used in citations of museum shell lots, and in the references to the literature.

ANSP, Academy of Natural Sciences of Philadelphia
 BM, British Museum
 BBM, Bernice P. Bishop Museum
 MCZ, Museum of Comparative Zoology
 HL, Herman Lemke collection
 Man. Conch., Manual of Conchology (second series)

The location of types is stated in the explanation of plates beginning on page 208.

TABLE 2.—Data on Material

Subspecies	Area	Collector†	Locality	Adults	Mean length	Length range	Dex- tral	Sinis- tral
REGION I.††								
Region of ridge complex 1, zones I and II.						<i>mm.</i>	<i>mm.</i>	
<i>A. a. forbesiana</i>	6??	Gulick	Waialae	11	17.0	16.5-18.5	10	10
<i>A. a. fuscostriata</i>	7??	Gulick	Palolo	39	16.5	15.5-18.5	3	46
<i>A. a. fuscostriata</i>	7??	Gulick	Waialae	14	17.0	15.5-18.5	..	26
<i>A. a. fuscostriata</i>	7??	Gulick	Wailupe	12	17.0	16.5-18.5	..	23
<i>A. a. simulator</i>	?	Gulick	Palolo	24	17.0	16.5-18.5	3	37
<i>A. a. buena</i>	?	All lots	....	11	17.0	16.5-18.5	..	21
Ridge complex 1, zones II and III.								
<i>A. a. muricolor</i>	1	Meinecke, 1926	41-4*	101	17.5	15.5-19.5	..	170
<i>A. a. muricolor</i>	1	Meinecke	41A-1*	11	18.5	16.5-19.5	..	12
<i>A. a. muricolor</i>	1	Meinecke	41B-4*	4	18.0	16.5-19.5	..	6
<i>A. a. waialaensis</i>	2	Meinecke, 1933	51Aa	16	18.5	17.5-19.5	..	20
<i>A. a. waialaensis</i>	2	Meinecke	50A*	16	18.0	17.5-19.5	1	23
<i>A. a. waialaensis</i>	2?	O. H. Emerson, 1916	....	16	19.5	18.5-20.5	..	23
<i>A. a. simulator</i> var. 1. . .	4	Meinecke	62	15	18.0	16.5-19.5	21	..
Ridge complex 2, zone III.								
<i>A. a. vittata</i> var. 1.	8	Meinecke	90A*	12	17.5	15.5-20.5	..	44
<i>A. a. vittata</i> var. 1.	8	Meinecke, 1923	91A*	37	18.0	16.5-19.5	..	72
<i>A. a. vittata</i> var. 1.	8	Meinecke, 1925	91A*	57	18.0	16.5-19.5	..	91
<i>A. a. vittata</i> var. 1.	8	Meinecke, 1926	91A*	92	18.0	16.5-20.5	..	115
<i>A. a. vittata</i> var. 1.	8	Meinecke, 1927-31	94A*	8	18.5	16.5-19.5	..	10
<i>A. a. vittata</i> var. 1.	8	Meinecke, 1927-31	95A*	12	18.0	17.5-19.5	..	13
<i>A. a. vittata</i> var. 2.	9	C. M. & R. A. Cooke	100-2*	53	18.5	16.5-21.5	..	75
<i>A. a. cinerea</i>	10	C. M. Cooke	100B-13	32	19.0	16.5-20.5	..	92
<i>A. a. cinerea</i>	10	C. M. Cooke	100B-12	17	19.5	18.5-20.5	..	36
<i>A. a. cinerea</i>	10	Meinecke, 1911-16	100B-7?	7	19.0	17.5-20.5	..	25
<i>A. a. cinerea</i>	10?	Wilder, 50504	....	62	19.5	17.5-21.5	..	89
<i>A. a. cinerea</i>	10	R. A. Cooke, 58138	....	29	20.0	17.5-21.5	..	31
Region of ridge complex 3, zone II.								
<i>A. a. globosa</i>	?	All lots	....	20	17.5	16.5-18.5	23	..
Ridge complex 3, zone II.								
<i>A. a. simulans</i>	16	Lemke	121-2	8	17.5	16.5-17.5	..	10
<i>A. a. simulans</i> var. 1. . .	17	Lemke & Anderson	121, 121-1	10	17.0	15.5-17.5	..	17

†† For explanation of regions, ridge complexes, and zones, see pp. 189, 190, and 193, and fig. 8, p. 195.

† Used for plotting on map, fig. 8.

‡ Unless otherwise stated all catalog numbers are those of the Bishop Museum.

* Asterisk indicates localities that were plotted from memory or prior to 1932.

? A question mark denotes there is some doubt concerning the correct plotting of a locality.

?? For two question marks, see explanation in text, p. 13.

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector¶	Locality	Adults	Mean length mm.	Length range mm.	Dex- tral	Sinis- tral
Ridge complex 3, zone III.								
† <i>A. a. vittata</i>	12	R. A. & C. M. Cooke, 58284, 22119	100E-1*	16	18.5	16.5-20.5	..	27
† <i>A. a. albofasciata</i>	13?	Wilder & Thurston	100A-1?	20	19.0	17.5-20.5	44	4
<i>A. a. albofasciata</i> var. 1	14??	J. S. Emerson	....	16	19.0	17.5-20.5	..	34
† <i>A. a. oliveri</i>	15?	O. H. & J. S. Emerson	120-1?	35	19.0	17.5-21.5	..	110
† <i>A. a. rubidipicta</i>	11	Meinecke, 1921	110*	119	19.5	16.5-21.5	..	166
† <i>A. a. rubidipicta</i>	11	Meinecke, 1922	110*	65	19.0	17.5-20.5	..	123
† <i>A. a. rubidipicta</i>	11	Meinecke, 1927	110*	76	19.5	16.5-21.5	..	100
† <i>A. a. rubidipicta</i>	11	Meinecke, 1929	110*	49	19.0	15.5-20.5	..	64
Ridge complex 4, zone II.								
† <i>A. a. simulans</i> var. 2..	19	Meinecke	151B*	12	18.5	16.5-19.5	..	33
Ridge complex 4, zone III.								
† <i>A. a. rubidipicta</i> var. 2.	18?	Wilder	Kahauiki	8	20.0	19.5-21.5	..	8
Ridge complex 4, probably zone III.								
<i>A. a. rubidipicta</i> var. 1.	?	Wilder	Kalihi	18	19.5	18.5-20.5	9	16
<i>A. a. rubidipicta</i> var. 3.	?	Wilder	Moanalua	75	19.5	17.5-21.5	..	93
REGION II.								
Ridge complex 5, zone II.								
† <i>A. a. ovum</i> var. 1.....	21	Meinecke	162B*	16	18.5	16.5-19.5	36	..
<i>A. a. ovum</i> var. 1.....	21?	Thurston	....	8	18.0	16.5-19.5	13	..
Ridge complex 5, zone III.								
† <i>A. a. ovum</i>	22	Meinecke	162C*	7	19.0	17.5-20.5	..	12
<i>A. a. ovum</i>	22?	Wilder, 50525	....	17	20.0	18.5-22.5	..	19
† <i>A. a. ovum</i> var. 2.....	23	Meinecke	162D*	22	19.5	17.5-20.5	..	33
† <i>A. a. ovum</i> var. 3.....	20	Meinecke & unlocal- ized J. S. & O. H. Emerson lots	163*	9	19.0	16.5-20.5	..	21
Ridge complex 6, zone II.								
† <i>A. a. pilsbryi</i>	26?	Cooke & Judd	170-1?	5	17.5	15.5-18.5	7	..
Ridge complex 6, zone III.								
<i>A. a. bruneola</i> var. 2..	25	Cooke & Judd	....	61	20.0	18.5-21.5	77	..
† <i>A. a. bruneola</i> var. 2..	25	Lemke	170C-6*	41	20.0	16.5-21.5	56	..
† <i>A. a. ovum</i> var. 2.....	24	Meinecke	174*	14	20.0	17.5-22.5	..	30
Ridge complex 7, zone II.								
† <i>A. a. laurani</i>	27	Meinecke	191*	7	18.5	17.5-19.5	..	17
† <i>A. a. laurani</i>	27A?	Cooke, Judd & Thurston	....	18	19.0	16.5-20.5	31	..
Ridge complex 7, zone III.								
† <i>A. a. bruneola</i>	28	Meinecke, 1926	182	9	19.0	17.5-20.5	12	..
† <i>A. a. bruneola</i> var. 1..	29	Meinecke, 1913	183?	19	20.0	18.5-22.5	2	32
† <i>A. a. bruneola</i> var. 1..	29	Meinecke, 1935	183	7	..	19.5-20.5	..	13
† <i>A. a. aureola</i>	30	Meinecke, 1913	184	12	20.5	19.5-22.5	1	47
† <i>A. a. aureola</i>	30	Meinecke, 1926	184	19	20.5	18.5-23.5	2	40
† <i>A. a. aureola</i>	30	Meinecke, 1932	187?	12	19.0	18.5-20.5	19	1
<i>A. a. aureola</i>	30	Meinecke, 1933	187	3	..	18.5-20.5	4	..
† <i>A. a. aureola</i>	30	Meinecke	185	10	20.0	18.5-21.5	..	16
† <i>A. a. aureola</i> var. 1...	31	Meinecke	190A*	10	18.5	17.5-20.5	17	..
Ridge complex 8, zone I.								
† <i>A. a. roseata</i>	37?	All lots	....	17	18.0	16.5-19.5	55	16
Ridge complex 8, zone II?								
† <i>A. a. parvicolor</i>	36??	Gulick	....	19	18.0	16.5-19.5	24	9

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector¶	Locality	Adults	Mean	Length	Dex-	Sinis-
					length	range			tral	tral
					mm.	mm.		
Ridge complex 8, zone III.								
<i>A. a. turgida</i>	35	Meinecke, 1913	202B	15	18.5	17.5-19.5	12	19
† <i>A. a. turgida</i>	35	Meinecke, 1920	202B	31	19.0	17.5-21.5	35	15
† <i>A. a. turgida</i>	35	Meinecke, 1934	202B	9	19.0	16.5-20.5	15	2
<i>A. a. turgida</i>	35	Wildner, 50598	....	170	19.0	16.5-22.5	201	60
<i>A. a. turgida</i>	35?	J. S. Emerson, 102218	....	121	19.5	16.5-21.5	228	..
<i>A. a. turgida</i>	35?	J. S. Emerson, 102218	....	107	19.5	16.5-22.5	..	175
† <i>A. a. meadowsi</i>	34	Meinecke	212b	11	19.0	17.5-21.5	..	17
† <i>A. a. meadowsi</i>	34	Meinecke	213a	10	19.5	17.5-21.5	..	18
† <i>A. a. meadowsi</i> var. 2.	33	Meinecke	200Ca*	7	21.0	18.5-22.5	..	18
† <i>A. a. meadowsi</i> var. 2.	33	Meinecke	201C	5	21.5	20.5-22.5	..	11
† <i>A. a. waimaluensis</i> ...	32	Meinecke	202C	9	20.5	19.5-21.5	..	11
† <i>A. a. waimaluensis</i> ...	32	Meinecke	203C	7	20.0	18.5-20.5	..	14
REGIONS II?, IIIa.								
Ridge complex 9, zone II.								
† <i>A. a. perplexa</i>	40	Meinecke	222*	11	18.5	17.5-20.5	14	19
† <i>A. a. perplexa</i>	40	Meinecke	221½*	17	18.5	16.5-20.5	24	17
† <i>A. a. perplexa</i>	40?	Cooke	....	45	18.5	15.5-20.5	54	4
† <i>A. a. perplexa</i>	40?	Wildner	....	129	18.0	15.5-21.5	74	63
† <i>A. a. nigripicta</i> var. 1.	44?	Wildner	....	27	18.5	15.5-20.5	26	7
<i>A. a. nigripicta</i> var. 1.	44?	Cooke	....	23	17.5	16.5-19.5	41	1
<i>A. a. nigripicta</i> var. 1.	44?	J. S. Emerson, 10717	....	51	18.0	16.5-20.5	105	..
<i>A. a. nigripicta</i> var. 1.	44?	J. S. Emerson, 10718	....	110	19.0	16.5-22.5	..	201
<i>A. a. chromatacme</i>								
var. 1	41	Meinecke	231*	68	18.5	16.5-20.5	13	102
† <i>A. a. chromatacme</i> ...	42	Meinecke	232	33	19.0	16.5-20.5	1	73
† <i>A. a. chromatacme</i> ...	42	Meinecke	234*	35	19.0	17.5-20.5	..	93
<i>A. a. chromatacme</i> ...	42	Meinecke	230B?	16	19.0	16.5-21.5	48	..
† <i>A. a. chromatacme</i> ...	42	Meinecke	235*	85	19.0	17.5-21.5	69	71
† <i>A. a. chromatacme</i> ...	42	Meinecke	236*	65	19.0	16.5-22.5	34	88
† <i>A. a. chromatacme</i>								
var. 2	43	Meinecke	237*	23	18.5	16.5-21.5	49	2
Ridge complex 9, zone III.								
† <i>A. a. cookei</i> var. 1....	39	Meinecke	211B	7	19.0	17.5-20.5	..	27
<i>A. a. cookei</i>	45?	Wildner, 50594	....	116	19.0	17.5-21.5	..	142
<i>A. a. cookei</i>	45?	Wildner, 50595	....	12	19.0	17.5-20.5	13	..
<i>A. a. cookei</i>	45?	Baldwin & C. H. Cooke	....	8	20.0	18.5-21.5	12	..
<i>A. a. cookei</i>	45?	C. M. & R. A. Cooke	....	12	20.0	17.5-21.5	11	6
† <i>A. a. cookei</i>	45	Meinecke	226*	6	20.0	17.5-21.5	15	..
† <i>A. a. simulacrum</i>	46	Meinecke	228a	8	20.0	18.5-21.5	..	13
† <i>A. a. simulacrum</i>	46	Meinecke	228*	29	19.5	18.5-21.5	..	44
† <i>A. a. simulacrum</i>	46	Meinecke	229*	17	20.5	19.5-22.5	..	31
† <i>A. a. nigripicta</i>	50	Meinecke	237b	19	18.5	17.5-19.5	18	18
† <i>A. a. nigripicta</i>	50	Meinecke	237c	8	19.0	17.5-20.5	..	13
† <i>A. a. nigripicta</i>	50	Meinecke	237d	9	19.0	16.5-20.5	..	16
<i>A. a. nigripicta</i>	50	Thurston	....	65	19.0	16.5-20.5	27	62
† <i>A. a. cookei</i> var. 2....	49	Meinecke	237f	16	19.0	17.5-20.5	25	..
† <i>A. a. cookei</i> var. 2....	49	Meinecke	237fa	7	19.5	18.5-20.5	8	..
† <i>A. a. nigripicta</i> var. 2.	48	Meinecke	237h	13	19.5	18.5-20.5	22	..
† <i>A. a. nigripicta</i> var. 2.	48A	Meinecke	238a-238b	17	19.5	18.5-21.5	..	27
† <i>A. a. rubidilinea</i>	47	Meinecke	239a	7	20.5	18.5-21.5	..	8
† <i>A. a. rubidilinea</i>	47	Meinecke	220A?	11	19.5	18.5-21.5	..	22
REGION IIIa.								
Ridge complex 10, zone II.								
† <i>A. a. albipraetexta</i> ...	63?	Meinecke	231B*	22	18.0	16.5-20.5	..	45
† <i>A. a. albipraetexta</i> ...	63?	Meinecke	232B*	21	19.0	17.5-20.5	..	35
† <i>A. a. albipraetexta</i> ...	64	Lemke	233B-1*	14	19.0	16.5-20.5	13	6
Ridge complex 10, zone III.								
† <i>A. a. ewaensis</i> var. 1..	51	Meinecke	234B*	5	18.5	17.5-19.5	3	6

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector†	Locality	Adults	Mean length	Length range	Dex- tral	Sinis- tral
REGION III.								
Ridge complex 11, zone II.								
					mm.	mm.		
<i>A. a. griseibasis</i>	65??	J. S. & O. H. Emerson	....	21	17.5	15.5-20.5	46	1
<i>A. a. polymorpha</i> var. 1 ..?		J. S. Emerson	....	15	18.0	16.5-19.5	18	5
† <i>A. a. flavitincta</i>	69	Meinecke	230G*	29	17.0	15.5-18.5	65	6
† <i>A. a. flavitincta</i>	69	Meinecke	231G?	23	17.0	15.5-17.5	32	..
† <i>A. a. flavitincta</i>	69	Meinecke	231G	41	17.0	15.5-17.5	64	12
<i>A. a. flavitincta</i>	69	Meinecke	232G*	47	16.5	15.5-18.5	17	80
† <i>A. a. lineipicta</i>	70	Meinecke	232Ga	17	17.0	15.5-18.5	..	20
<i>A. a. lineipicta</i>	70	Meinecke	233G*	9	18.5	17.5-20.5	16	..
† <i>A. a. lineipicta</i>	70	Meinecke	234G	25	17.0	15.5-18.5	33	1
† <i>A. a. lemkei</i> var. 1....	68?	Lemke	233Ga?	24	18.0	16.5-20.5	23	29
† <i>A. a. lemkei</i>	67?	Lemke	230E-1?	46	18.0	15.5-21.5	7	50
<i>A. a. fumositincta</i>	71	Meinecke	240*	13	17.5	16.5-19.5	..	46
† <i>A. a. fumositincta</i>	71	Welch	241-1*	8	16.5	15.5-17.5	..	27
† <i>A. a. fumositincta</i>	71	Russ	241-1?	8	16.5	15.5-17.5	1	10
† <i>A. a. fumositincta</i>	71	Russ	240-1- 241-1a?	11	16.5	15.5-17.5	2	13
† <i>A. a. fumositincta</i>	71	Welch	241-2*	15	17.0	15.5-18.5	1	44
† <i>A. a. fumositincta</i>	71	Welch	241-3*	6	16.5	15.5-17.5	..	17
Ridge complex 11, zone III.								
† <i>A. a. ewaensis</i> var. 3..	52	Meinecke	243-2*	9	18.5	16.5-19.5	12	4
† <i>A. a. ewaensis</i> var. 3..	52	Welch	243-4*	7	17.0	16.5-18.5	..	9
† <i>A. a. ewaensis</i> var. 2..	53	Meinecke	244*	15	16.5	15.5-18.5	..	33
† <i>A. a. ewaensis</i> var. 4..	54	Meinecke	244-3?	12	17.5	15.5-18.5	..	16
† <i>A. a. ewaensis</i> var. 4..	54	Meinecke	246*	7	17.5	16.5-19.5	..	13
Ridge complex 12, zone II.								
† <i>A. a. virgatifulva</i>	73?	Wilder	....	58	18.0	16.5-21.5	20	52
<i>A. a. virgatifulva</i> var. 2	74	Meinecke	250*	6	16.5	15.5-17.5	21	..
† <i>A. a. virgatifulva</i> var. 2	74?	Wilder, 50571	....	32	17.0	15.5-19.5	24	13
<i>A. a. virgatifulva</i> var. 2	74?	Wilder, 50573	....	32	17.5	14.5-20.5	23	13
Ridge complex 12, zone III.								
† <i>A. a. ewaensis</i> var. 5..	55	Meinecke	240L-1-1a	11	17.5	16.5-18.5	14	39
† <i>A. a. ewaensis</i> var. 5..	55	Meinecke	240L-1	11	17.5	15.5-19.5	..	17
† <i>A. a. ewaensis</i>	56	Meinecke	240L-4	11	17.5	16.5-18.5	12	4
† <i>A. a. ewaensis</i>	56	Meinecke	240L-6	7	17.5	15.5-18.5	9	..
† <i>A. a. ewaensis</i> var. 6..	57	Meinecke, 121935- 121936	252-1-2?	29	16.5	15.5-17.5	25	24
† <i>A. a. ewaensis</i> var. 6..	57	Meinecke, 121937- 121938	253?	31	17.0	15.5-18.5	28	15
† <i>A. a. ewaensis</i> var. 7..	58	Meinecke	256	7	17.0	16.5-18.5	..	15
† <i>A. a. ewaensis</i> var. 7..	58	Meinecke	257	18	18.0	15.5-20.5	18	11
Ridge complex 13, zone II.								
† <i>A. a. virgatifulva</i> var. 1	75?	Thurston, 130725	....	8	17.5	16.5-18.5	..	14
† <i>A. a. tuberosus</i> var. 2..	60	Meinecke	261*	6	18.0	16.5-19.5	4	10
Ridge complex 13, zone III.								
† <i>A. a. ewaensis</i> var. 8..	59	Meinecke	261-262?	18	19.0	17.5-20.5	..	42
† <i>A. a. ewaensis</i> var. 8..	59?	Wilder	....	23	19.0	17.5-20.5	7	25
Portion of ridge complex 14, zone II.								
† <i>A. a. tuberosus</i> var. 4..	76?	Meinecke, 1918	260A?	17	18.0	15.5-21.5	22	2
† <i>A. a. tuberosus</i> var. 4..	76?	Meinecke, 1924	260A?	11	18.0	16.5-19.5	..	29
<i>A. a. tuberosus</i> var. 4..	76?	O. H. Emerson	....	7	18.0	16.5-18.5	2	15
<i>A. a. tuberosus</i> var. 4..	76?	Wilder	....	27	18.0	15.5-20.5	20	19
<i>A. a. tuberosus</i> var. 5..	?	Wilder, 50575	....	56	16.5	15.5-18.5	60	15
<i>A. a. tuberosus</i> var. 5..	?	L. A. Thurston	....	33	17.0	15.5-18.5	..	..

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector†	Locality	Adults	Mean length	Length range	Dex- tral	Sin- tral
REGION IV.								
Possibly in the region of ridge complexes 14, 15, zone I and lower zone II.								
					mm.	mm.		
<i>A. a. coniformis</i> . . . . .	..	Gulick	Ahonui & Kalaikoa	14	18.0	16.5-20.5	14	..
<i>A. a. coniformis</i> . . . . .	..	Gulick	Wahiawa	23	17.5	16.5-20.5	28	3
<i>A. a. versicolor</i> . . . . .	..	Gulick	Ahonui	14	17.0	14.5-18.5	..	56
<i>A. a. versicolor</i> . . . . .	..	Gulick	Kalaikoa	12	17.0	15.5-19.5	..	28
<i>A. a. gulickii</i> . . . . .	..	Gulick	Ahonui	8	18.0	16.5-18.5	19	9
<i>A. a. gulickii</i> var. 1. . . . .	..	Gulick	Ahonui	18	18.5	17.5-19.5	21	14
<i>A. a. gulickii</i> var. 2. . . . .	..	Gulick	Kalaikoa	8	16.5	15.5-18.5	10	17
<i>A. a. flavida</i> . . . . .	..	Gulick	Ahonui & Kalaikoa	8	16.5	15.5-17.5	47	5
Ridge complex 14, zone II.								
† <i>A. a. steeli</i> var. 1.	79	Wilder	....	18	19.0	17.5-20.5	26	..
† <i>A. a. steeli</i>	80	Russ	271	11	19.5	17.5-20.5	..	20
† <i>A. a. steeli</i>	80?	O. H. Emerson	....	19	19.5	17.5-21.5	..	34
† <i>A. a. steeli</i>	80?	Wilder, 50577	....	41	19.0	17.5-20.5	18	32
† <i>A. a. steeli</i>	80?	Wilder, 50580	....	13	19.0	17.5-20.5	..	16
<i>A. a. punicea</i>	81??	Wilder, 50581	....	6	19.0	17.5-20.5	3	4
† <i>A. a. punicea</i>	81??	Wilder, 50583	....	56	20.0	17.5-22.5	..	66
<i>A. a. punicea</i> var. 1.	82	Wilder, 50578	....	17	19.5	17.5-21.5	12	11
† <i>A. a. tuberosus</i> var. 3.	77	Lemke	274	15	19.5	17.5-21.5	19	..
<i>A. a. tuberosus</i> var. 3.	77	Wilder, 10448	....	7	19.0	18.5-20.5	9	1
Ridge complex 14, zone III.								
<i>A. a. irwini</i>	61?	Wilder	....	14	18.5	17.5-19.5	..	22
† <i>A. a. irwini</i>	61?	Meinecke	275?	13	19.0	17.5-21.5	4	14
† <i>A. a. irwini</i> var. 1.	62?	Meinecke, 1918	277?	45	18.0	16.5-20.5	..	60
† <i>A. a. irwini</i> var. 1.	62?	Meinecke, 1918	277?	13	19.0	17.5-20.5	19	..
† <i>A. a. irwini</i> var. 1.	62?	Meinecke, 1923	277?	10	18.5	16.5-20.5	5	13
Ridge complex 15, zone II.								
<i>A. a. lilacea</i>	*83b??	Gulick	Ahonui	17	19.0	17.5-20.5	25	..
<i>A. a. lilacea</i>	*83b??	Gulick	Kalaikoa	14	19.0	17.5-20.5	21	..
† <i>A. a. lilacea</i> var. 1.	83	Meinecke	280*	18	18.5	16.5-20.5	57	..
† <i>A. a. lilacea</i> var. 1.	83	Russ	280-1-280*	27	18.5	16.5-20.5	37	..
<i>A. a. lilacea</i> var. 1.	83?	Wilder	....	23	18.5	17.5-19.5	14	11
† <i>A. a. lilacea</i> var. 1.	83a	Meinecke	281-2*	10	18.0	16.5-20.5	9	12
Ridge complex 15, zone III.								
† <i>A. a. lilacea</i> var. 2.	84	Meinecke	282-3	5	19.0	17.5-20.5	10	..
† <i>A. a. poamohonesis</i>	101	Meinecke	283-1-3-4	10	19.5	17.5-20.5	15	..
† <i>A. a. poamohonesis</i>	101	Meinecke	284-2	18	19.5	18.5-21.5	34	..
† <i>A. a. roseipicta</i>	102	Meinecke	285-3-286	32	19.0	17.5-19.5	55	..
<i>A. a. roseipicta</i>	102?	O. H. Emerson	....	29	19.0	17.5-21.5	39	..
<i>A. a. roseipicta</i>	102?	Wilder, 50563	....	55	19.0	16.5-21.5	65	..
† <i>A. a. roseipicta</i> var. 1.	103	Meinecke	287-1-3	18	19.5	18.5-20.5	30	..
† <i>A. a. roseipicta</i> var. 1.	103	Meinecke	288	6	20.0	18.5-21.5	10	..
† <i>A. a. roseipicta</i> var. 1.	103	Meinecke	289-1a	13	19.0	18.5-20.5	23	..
† <i>A. a. aloha</i>	100?	Wilder	....	169	19.0	17.5-24.5	191	..
† <i>A. a. aloha</i>	100?	Thurston	....	19	19.0	17.5-20.5	59	..
† <i>A. a. aloha</i> var. 1.	100?	Wilder	....	19	19.5	18.5-21.5	36	..
Possibly in the region of ridge complex 16, zone I or lower zone II.								
<i>A. a. apexalba</i> . . . . .	..	Gulick	Ahonui	12	17.5	16.5-19.5	15	..
<i>A. a. apexalba</i> . . . . .	..	Gulick	Wahiawa	31	17.0	14.5-19.5	26	62
<i>A. a. wahiawa</i> . . . . .	..	Gulick	Wahiawa	15	17.5	16.5-18.5	38	3

* See figure 7, page 194.

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector†	Locality	Adults	Mean length	Length range	Dex- tral	Sinis- tral
					mm.	mm.		
Ridge complex 16, zone II.								
† <i>A. a. suturafusca</i>	86	Meinecke	280K-1*	32	19.0	17.5-21.5	21	39
<i>A. a. suturafusca</i>	86?	Wildner	....	67	19.0	15.5-22.5	70	9
† <i>A. a. glaucopicta</i>	87	Meinecke	280K-2	10	19.0	15.5-20.5	14	9
† <i>A. a. brunosa</i>	88	Meinecke	280L-2	10	19.0	17.5-20.5	20	..
† <i>A. a. brunosa</i>	88	Meinecke	280L-4	9	18.5	17.5-20.5	..	13
† <i>A. a. suturalba</i>	90	Lemke	290AA-8	22	19.5	18.5-21.5	34	..
† <i>A. a. suturalba</i>	90	Welch	290AA-8	13	19.5	18.5-20.5	32	..
<i>A. a. suturalba</i>	90?	Wildner	....	44	19.0	16.5-21.5	58	..
† <i>A. a. suturafusca</i> var. 2	89	Meinecke, 1914	290*	57	19.5	17.5-21.5	102	7
† <i>A. a. suturafusca</i> var. 2	89	Meinecke, 1917	290*	63	19.0	17.5-21.5	11	72
<i>A. a. apicata</i>	92?	Gulick	Helemano	14	19.0	17.5-20.5	15	..
† <i>A. a. cervinivea</i>	93	Russ	300-4*	17	19.5	18.5-20.5	17	..
<i>A. a. cervinivea</i>	93	Meinecke, 1917	300-6	10	18.0	16.5-19.5	26	9
<i>A. a. cervinivea</i>	93	Meinecke, 1916	300-6-301-2*	14	18.5	17.5-20.5	14	11
† <i>A. a. cervinivea</i>	93?	Wildner, 50631	....	124	19.5	17.5-22.5	71	58
† <i>A. a. cervinivea</i>	93?	Wildner, 50566	....	19	19.0	17.5-21.5	14	8
† <i>A. a. beata</i> var. 1.....	94	Meinecke, 1916	302*	19	19.0	16.5-20.5	25	6
† <i>A. a. beata</i> var. 1.....	94	Meinecke, 1932	302*	8	19.0	17.5-19.5	9	5
† <i>A. a. beata</i> var. 1.....	94	Meinecke, 1916-17	291-3-5*	33	19.0	17.5-21.5	69	..
† <i>A. a. beata</i> var. 1.....	94	Meinecke, 1932	291-3-5*	5	19.5	17.5-21.5	11	..
† <i>A. a. beata</i> var. 1.....	94?	Wildner, 50568-50569	....	59	19.0	17.5-20.5	88	3
† <i>A. a. beata</i> var. 1.....	94-94a?	Meinecke, 1914	291-2-302?	40	19.0	17.5-20.5	108	..
Ridge complex 16, zone III.								
† <i>A. a. beata</i>	104	Meinecke	280L-6	8	18.5	17.5-19.5	6	9
† <i>A. a. beata</i>	104	Meinecke	280L-9	15	20.0	18.5-21.5	18	..
† <i>A. a. beata</i>	104	Meinecke	303	8	19.5	18.5-21.5	11	..
† <i>A. a. beata</i>	104	Russ	303	17	19.5	17.5-21.5	21	1
<i>A. a. beata</i>	104	Welch	304	7	19.5	18.5-21.5	11	..
† <i>A. a. beata</i>	104	Meinecke, 1932	305-306?	11	19.0	18.5-20.5	26	..
<i>A. a. beata</i>	104	Meinecke, 1916	302-304?	9	19.0	17.5-20.5	18	..
<i>A. a. beata</i>	104?	Thurston	....	52	19.0	17.5-20.5	98	..
<i>A. a. beata</i>	104?	Wildner	....	75	19.5	18.5-21.5	91	..
<i>A. a. roseipicta</i> var. 2.	105	Meinecke	280L-2	8	20.0	18.5-21.5	12	..
† <i>A. a. roseipicta</i> var. 2.	105	Meinecke	307-3-308-1	8	19.5	18.5-20.5	15	..
† <i>A. a. roseipicta</i> var. 2.	105	Meinecke, 1917	307-1a-1b	20	19.0	17.5-20.5	47	..
<i>A. a. roseipicta</i> var. 2.	105	Lemke	307-3	13	20.0	18.5-21.5	17	..
† <i>A. a. roseipicta</i> var. 2.	105	Russ, 1932	308-1	7	19.0	17.5-21.5	8	..
Ridge complex 17, zone II.								
<i>A. a. suturalba</i> var. 1..	91??	J. S. Emerson	....	32	18.5	16.5-20.5	40	6
<i>A. a. suturalba</i> var. 1..	91??	Gulick	....	13	18.5	17.5-19.5	18	..
† <i>A. a. apicata</i> var. 1... 95	95	Meinecke, 1933	312-2-5	22	19.0	18.5-20.5	33	..
† <i>A. a. apicata</i> var. 1... 95	95	Meinecke, 1932	310-312-4*	30	19.5	16.5-22.5	71	1
† <i>A. a. paalaensis</i>	106	Meinecke	313-3	12	18.5	17.5-20.5	15	..
<i>A. a. apicata</i> var. 2... 96?	96?	Wildner, 50510	....	89	19.0	16.5-22.5	113	2
Ridge complex 17, zone III.								
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke	313-1	6	19.0	17.5-20.5	7	..
<i>A. a. paalaensis</i> var. 1.	107	Meinecke, 1932	314-1	12	18.5	17.5-19.5	31	..
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke, 1933	314-1	10	20.0	18.5-21.5	14	..
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke, 1932	316-1-3	27	19.5	18.5-21.5	33	..
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke, 1933	316-1-3	19	19.5	18.5-20.5	37	..
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke, 1932	334*	25	20.0	18.5-21.5	40	..
† <i>A. a. paalaensis</i> var. 1.	107	Meinecke	336-1*	7	19.5	17.5-20.5	13	..
<i>A. a. paalaensis</i> var. 1.	107	O. H. Emerson	....	22	19.5	17.5-20.5	57	..
† <i>A. a. beata</i> var. 2..... 108	108	Meinecke	318	37	19.5	18.5-21.5	67	..
† <i>A. a. beata</i> var. 2..... 108	108	Meinecke	318a	9	20.0	18.5-22.5	14	..
† <i>A. a. paalaensis</i> var. 2.	109	Meinecke, 1929	337-1-2?	12	20.0	18.5-22.5	16	..
† <i>A. a. paalaensis</i> var. 2.	109	Meinecke	337-3	9	20.0	18.5-20.5	14	..
<i>A. a. paalaensis</i> var. 2.	109	Meinecke, 1932	337-1-3?	15	19.5	18.5-20.5	28	..
<i>A. a. paalaensis</i> var. 2.	109	Meinecke, 1932	337-1-3?	15	19.5	17.5-21.5	29	..
<i>A. a. paalaensis</i> var. 2.	109	Meinecke, 1928	337-1-3?	12	19.5	17.5-21.5	17	..
† <i>A. a. beata</i> var. 3..... 110	110	Meinecke	337-4	13	19.5	17.5-20.5	26	..
<i>A. a. beata</i> var. 3..... 110	110	Meinecke	338-339-1?	26	19.5	17.5-21.5	46	..
† <i>A. a. beata</i> var. 3..... 110	110	Meinecke	338	6	20.5	19.5-22.5	16	..
† <i>A. a. beata</i> var. 3..... 110	110	Meinecke	339-1a*	15	20.0	18.5-21.5	30	..
<i>A. a. beata</i> var. 3..... 110	110	Meinecke	338?	6	20.0	18.5-21.5	16	..

TABLE 2.—Data on Material—Continued

Subspecies	Area	Collector¶	Locality	Adults	Mean length mm.	Length range mm.	Dex- tral	Sinis- tral
Ridge complex 18, zone I.								
† <i>A. a. duplocincta</i>	97A??	J. S. Emerson	....	56	18.0	16.5-19.5	61	..
Ridge complex 18, zone II.								
† <i>A. a. apexfulva</i>	97	J. S. Emerson	Opauala	37	18.5	17.5-19.5	38	..
Ridge complex 18, zone III.								
† <i>A. a. kawaiiki</i>	99?	Wilder & Thurston	....	9	19.5	16.5-20.5	16	..
† <i>A. a. vespertina</i>	98?	All lots	....	22	19.5	17.5-21.5	43	..
Somewhere between ridge complex 18 and 19, or in ridge complex 17 or 18.								
<i>A. a. bakeri</i> . . . . .	..	J. S. Emerson & Judd	....	12	17.5	15.5-18.5	14	I
Probably ridge complex 19, zone I or lower zone II.								
<i>A. a. napus</i> . . . . .	..	Gulick	....	10	18.5	16.5-20.5	16	..
<i>A. a. leucozona</i> . . . . .	..	Gulick, ANSP 92656	....	78	17.5	15.5-19.5	164	..
<i>A. a. leucozona</i> . . . . .	..	J. S. Emerson	....	8	17.5	16.5-18.5	10	..
Ridge complex 19, zone II.								
† <i>A. a. paumotuensis</i>	111	Meinecke	431	14	18.5	16.5-20.5	54	..
† <i>A. a. oioensis</i>	114	Meinecke	460A	9	17.5	16.5-18.5	13	..
† <i>A. a. oioensis</i> var. 2	113	Meinecke	462*	21	18.5	16.5-19.5	56	..
<i>A. a. oioensis</i> var. 2	113?	Thurston	....	23	17.5	16.5-19.5	37	..
† <i>A. a. oioensis</i> var. 1	112	Meinecke	450	3	18.5	17.5-19.5	16	..
Ridge complex 20, zone I.								
† <i>A. a. wailensis</i>	117	Russ & Welch	....	14	18.5	15.5-20.5	57	..
Ridge complex 20, zone II.								
† <i>A. a. thiihiensis</i>	116	Welch	510-2a	5	18.0	16.5-19.5	10	..
Ridge complex 20, zone III.								
† <i>A. a. kahukuensis</i>	115?	Wilder & Thurston	....	22	19.5	17.5-21.5	55	..

SPECIES CONCEPT

The species concept of *Achatinella apexfulva* is the same as that maintained for *A. mustelina* (Welch, 1938). If two forms are found in the same locality or in adjacent localities and are not found to hybridize they are considered distinct species. If hybrids are found between two forms A and B one is considered a subspecies of the other.

In the "Manual of Conchology" (1912-1914, p. 275) the various forms of *Achatinella* are divided into three large sections: Section *Bulinella* Pfeiffer, section *Achatinellastrum* Pfeiffer, and section *Achatinella* sensu strictu. The forms of the third section are divided by Cooke into eight species: *A. lorata*, *A. cestus*, *A. vittata*, *A. turgida*, *A. apexfulva*, *A. decora*, *A. valida*, and *A. mustelina*. Pilsbry added three more, *A. leucorraphe*, *A. swiftii*, and *A. concavospira*, making 11 species in all. However, Pilsbry states:

It was hoped that characters might be found in the reproductive organs which would aid to indicate specific boundaries, but dissections of *A. lorata*, *vittata simulans*, and *mustelina* show no tangible structural differences.

A consistent arrangement of the species in linear order is impossible, as the group is formed of two parallel series which merge together in the less specialized median species of each.

The minor series consists of *apexfulva*, *turgida*, and *lorata*, species in which the apex is never black or dusky. These forms are confined to the Main range, but do not reach to either end.

In the greater series the tip of the apex is invariably dark in some species (*cestus*, *vittata*, *leucorraphe*), and is variable, either dusky or light, in others. The species are distributed over the whole length of both the main and the Waianae ranges.

An alternative and probably better grouping may be suggested. (1) Series of *lorata*, for *A. lorata*. (2) Series of *A. apexfulva*, for *A. apexfulva*, *turgida*, *saxifitii*, *leucorraphe*, *vittata*, *cestus*. (3) Series of *decora*, for *A. valida*, *decora*, *mustelina*, *conconvospira*.

Since the publication of the Manual large collections of *Achatinella* from a great number of carefully plotted localities have been acquired for study by the Bishop Museum. These collections contain many hitherto unknown intermediate forms and greatly enlarge the species concept that resulted from the scant amount of material available in 1914. It is interesting to note that Pilsbry's alternative grouping of forms of *Achatinella* sensu strictu is almost the same as that derived from the study of additional material. The main difference is that instead of having species grouped under a series, each series is considered a single species, species complex, or Rassenkreise (Rensch, 1938) because intergrades for the most part are found existing between the various species.

In most places live specimens of *A. apexfulva* are comparatively rare. A general idea of the scarcity of the species can be obtained by looking at table 2 (p. 15). Most of the large lots were collected prior to 1932 by J. S. Emerson, Wilder, Cooke, Thurston, and Meinecke. In most cases they represent accumulations of shells acquired by numerous visits to the same place. The more recently collected Meinecke material consists mostly of small lots.

Achatinella apexfulva varies greatly in form and color pattern in different parts of the Koolau Range. Large sectors, however, produce no forms of *A. apexfulva*, the shells having either died out or escaped discovery. From Palolo to Pauoa Valleys (fig. 7, p. 194) there is a big gap in localities of *A. apexfulva*. But from Nuuanu to Opaepala Gulch a nearly complete series of forms is found from ridge to ridge, the forms more or less intergrading. Where a great deal of careful collecting has been done on certain ridges such as those from Waimano to Waiawa and those between South Kaukonahua Stream and Opaepala Gulch, certain areas are found to contain defi-

nite color forms at different elevations. Moreover, a color form belonging to a definite area is separated from the color form of another area by a region containing shells which have an intermediate color pattern or a mixture of the color patterns of the areas on either side of it. The extent of these intermediate localities has not yet been well determined, for the work in the Koolau Range is still in the pioneer stage because of the rareness of the shells, the roughness of the terrain, and the vast extent of the Koolau Range. The shells in a border region between two areas may have a color pattern which is a mixture of those of an upper and lower area and is also intermediate between those of the shells occurring on parallel ridges on either side of the area. From a study of the carefully collected regions of the Koolau Range and a study of the collection as a whole, so that the trend in the differentiation of *Achatinella* is determined, *Achatinella sensu strictu* is grouped into the following six species: 1, *A. lorata* Férussac; 2, *A. apexfulva* Dixon; 3, *A. turbini-formis* Gulick; 4, *A. concavospira* Pfeiffer; 5, *A. decora* Férussac; 6, *A. mustelina* Mighels. This paper concerns only *A. apexfulva*; a discussion of species 1, 3, 4, and 5 will be reserved for future papers.

Subspecific groups will be used in this paper to group together the lower orders of forms of *A. apexfulva*, as is done for *A. mustelina* (Welch, 1938). The term "variety" will also denote that a particular form is closely related to a particular subspecies but has not enough distinctive characters to warrant its separation into a definite subspecies. All varieties will be numbered var. 1, var. 2, etc.

TAXONOMY

SYNOPSIS OF THE SUBSPECIES OF ACHATINELLA APEXFULVA DIXON

The following synopsis is purely an artificial grouping of forms that seem to be similar. No great detail will be attempted because so few really distinct characters exist beyond the shape and color of the embryonic whorls and size of the shells. The color pattern of the postembryonic whorls in some regions is of use, but very often it is of little aid since the same pattern may occur again and again in widely separated forms. Unless otherwise stated the color pattern of the shell is the color of the last two postembryonic whorls.

A. Embryonic whorls bicolored. First embryonic whorl a dark color (black, gray, light brown), remaining embryonic whorls white, cream buff, or some shade of yellowish white. The dark band or line usually fades out, on the first quarter or first half of the second embryonic whorl, into the ground color or into a light yellowish-white band or

line at the lower edge of the whorl, which finally may fade out entirely on the last quarter whorl.

a. Embryonic whorls pointed. First embryonic whorl light reddish brown (pecan brown, army brown, walnut brown, sepia), remaining embryonic whorls usually white. Exceptions are *A. a. buena*, *A. a. cinerea*, and *A. a. hanleyana*, which have yellow or yellow-banded embryonic whorls (such as pinkish buff, tilleul buff, cinnamon buff).

I. Small usually lowland forms, occurring mostly in zone II,¹ regions I, Ia, which may be white or buff, lined, banded, streaked, or spotted with brown or reddish brown, or the patterns may be gray or gray brown. The mean length ranges from 15.5 to 20.5 mm.

Group of *A. a. cestus* Newcomb

1. *A. a. muricolor*, new subspecies
2. *A. a. waialaensis*, new subspecies
3. *A. a. forbesiana* Pfeiffer
4. *A. a. fuscostriata*, new subspecies
5. *A. a. immotabilis* Smith
6. *A. a. cestus* Newcomb
7. *A. a. simulator* Pilsbry and Cooke
8. *A. a. buena*, new subspecies
9. *A. a. globosa* Pfeiffer
10. *A. a. hanleyana* Pfeiffer
11. *A. a. simulans* Reeve

II. White obese forms lined with reddish brown having a mean length of 18.5 to 20.5 mm., and occurring in zone III, regions I, Ia. They are larger than shells belonging to the group of *A. a. cestus*.

Group of *A. a. vittata* Reeve

1. *A. a. vittata* Reeve
2. *A. a. cinerea* Sykes
3. *A. a. albofasciata* Smith
4. *A. a. oliveri*, new subspecies
5. *A. a. rubidipicta*, new subspecies

b. Embryonic whorls blunt, usually banded with yellow. Forms occurring between North Waiawa Stream and the upper portion of the North-South Kaukonahua Ridge.

I. The color pattern may have the white ground tinted or banded with buff or gray, or the ground may be buff or a light shade of gray. The shell is usually lined or banded with gray, reddish brown, or

¹ For discussion of zones and regions see pp. 189, 190, and figs. 7, 8, pp. 194, 195.

brown and is found in zone II, region III, from Waiawa to Kipapa Gulch.....Group of *A. a. polymorpha* Gulick

1. *A. a. polymorpha* Gulick
2. *A. a. flavitincta*, new subspecies
3. *A. a. lemkei*, new subspecies
4. *A. a. lineipicta*, new subspecies
5. *A. a. fumositincta*, new subspecies

Note.—Some specimens of *A. a. polymorpha* and its varieties lack the dark color, such as black or gray, on the first embryonic whorl.

II. The pattern is a strongly axially streaked one, the color brownish gray or light tan, impressed sutural band white, brown, or buff. The forms are limited to zone II, region III, between Kipapa Gulch and South Kaukonahua Stream. Exception, *A. a. tubersans*, which has banded forms that may or may not be strongly axially streaked.

Group of *A. a. leucorraphe* Gulick

1. *A. a. virgatifulva*, new subspecies
2. *A. a. leucorraphe* Gulick
3. *A. a. tubersans* Gulick

III. White shells lined or banded with reddish brown, gray, and sometimes yellow occurring in zone III, region III.

Group of *A. a. irwini* Pilsbry and Cooke

1. *A. a. ewaensis*, new subspecies
2. *A. a. irwini* Pilsbry and Cooke

B. Embryonic whorls unicolored.

a. Embryonic whorls white.

I. Embryonic whorls very pointed to moderately pointed. Small shells from the lowland zone or zones I and II, region II; mean length from 17.5 to 18.5 mm.. .Group of *A. a. pilsbryi*, new subspecies

1. *A. a. pilsbryi*, new subspecies
2. *A. a. roseata*, new subspecies
3. *A. a. laurani*, new subspecies
4. *A. a. parvicolor*, new subspecies

A. a. laurani and *A. a. parvicolor* are intermediate forms between a lower smaller race with very pointed embryonic whorls, occurring in lower zone I, and a large obese race of shells inhabiting an upper zone or zone III. I am merely putting them in the subspecific group of *A. a. pilsbryi* because they are closer to the form of *pilsbryi* than to the upper group of *A. a. turgida*.

II. Large obese shells found mostly in zone III, region II, and zone II, region IIIa, between Moanalua and Waiawa Streams. Embryonic whorls moderately pointed, usually white but sometimes cream buff; mean length, 18.5 to 21.5 mm.

Group of *A. a. turgida* Newcomb

1. *A. a. ovum* Pfeiffer
2. *A. a. bruneola*, new subspecies
3. *A. a. aureola*, new subspecies
4. *A. a. waimaluensis*, new subspecies
5. *A. a. turgida* Newcomb
6. *A. a. meadowsi*, new subspecies
7. *A. a. perplexa* Pilsbry and Cooke
8. *A. a. nigripicta*, new subspecies
9. *A. a. cookei* Baldwin
10. *A. a. simulacrum* Pilsbry and Cooke
11. *A. a. rubidilinea*, new subspecies
12. *A. a. chromatacme* Pilsbry and Cooke
13. *A. a. griseibasis*, new subspecies
14. *A. a. albipraetexta*, new subspecies

Note.—*A. a. chromatacme* differs from the remaining subspecies of this group in having shells with darker embryonic whorls of tan or yellowish brown. *A. a. griseibasis* has more loosely coiled embryonic whorls which are intermediate between the embryonic whorls of the groups of *A. a. turgida* and *A. a. leucorraphe*.

b. Embryonic whorls white in a few forms, but usually they are tinted with buff or yellow, or are a deep shade of yellow or yellowish brown.

I. Small shells probably from zone I or lower zone II, region IV, between South Kaukonahua Stream and North Helemano Stream. All forms extinct as far as is known. Gray or gray-brown lined or streaked color patterns, embryonic whorls white or tinted cream color.

Group of *A. a. coniformis* Gulick

1. *A. a. coniformis* Gulick
2. *A. a. apexalba*, new subspecies
3. *A. a. versicolor* Gulick
4. *A. a. wahiarwa*, new subspecies

II. Shells with color patterns of light pastel shades of pink, yellow, deep cream, or blue gray, usually lightly axially streaked with similar colors darker than the ground color. They occur in zone II and probably zone I, region IV, between South Kaukonahua Stream and

North Kaukonahua Stream. Exceptions are *A. a. steeli*, *A. a. gulickii*, which are banded with reddish brown or dark gray and strongly axially streaked; *A. a. flavidus*, which may lack streaking or may be banded with brown. Group of *A. a. lilacea* Gulick

1. *A. a. gulickii* Smith
2. *A. a. flavida* Gulick
3. *A. a. lilacea* Gulick
4. *A. a. glaucopicta*, new subspecies
5. *A. a. punicea*, new subspecies
6. *A. a. steeli*, new subspecies

III. Strongly axially streaked brown and gray color forms from zone II and the lower part of zone III, region IV, between Poamoho Stream and Kawainui Gulch. Embryonic whorls usually a dark yellowish brown. Exceptions are *A. a. brunosa* and *A. a. kawaiiki*, which have lighter embryonic whorls. Group of *A. a. apicata* Newcomb

1. *A. a. brunosa*, new subspecies
2. *A. a. suturafusca*, new subspecies
3. *A. a. suturalba*, new subspecies
4. *A. a. apicata* Newcomb
5. *A. a. paalaensis*, new subspecies
6. *A. a. kawaiiki*, new subspecies

IV. Not markedly axially streaked, white or light color patterns. The color is mostly light pink, light gray, flesh tints, usually banded over white or colors almost solid on the last two whorls. Exceptions are the dark gray color pattern of *A. a. cervixnivea*, the reddish-brown pattern of *A. a. beata*, which may resemble typical *apexfulva*, and also *A. a. kahukuensis* which has a white spire and a yellow base. These forms inhabit zone III and the upper part of zone II, region IV, from North Kaukonahua Stream to the Malaekahana-Kaluakauila Ridge. Group of *A. a. aloha* Pilsbry and Cooke

1. *A. a. aloha* Pilsbry and Cooke
2. *A. a. roseipicta*, new subspecies
3. *A. a. poamohoensis*, new subspecies
4. *A. a. cervixnivea* Pilsbry and Cooke
5. *A. a. beata* Pilsbry and Cooke
6. *A. a. vespertina* Baldwin
7. *A. a. kahukuensis* Pilsbry and Cooke

V. Small lowland forms from zones I and II, region IV, north-west of Helemano Stream. Embryonic whorls white, cream, or yellow. Mean length, 16.5 to 18.5 mm.

Group *A. a. apexfulva* Dixon

1. *A. a. apexfulva* Dixon
2. *A. a. duplocincta* Pilsbry and Cooke
3. *A. a. bakeri*, new subspecies
4. *A. a. napus* Pfeiffer
5. *A. a. leucozona* Gulick
6. *A. a. paumaluensis*, new subspecies
7. *A. a. oioensis*, new subspecies
8. *A. a. ihiihiensis*, new subspecies
9. *A. a. wailelensis*, new subspecies

GROUP OF *A. A. CESTUS* NEWCOMB

ACHATINELLA APEXFULVA FORBESIANA Pfeiffer

PLATE I, FIGURE 2; PLATE 4, FIGURES 5-6a

Achatinella forbesiana PFEIFFER, Proc. Zool. Soc. London, 1855, p. 5, pl. 30, fig. 16.

Achatinella cestus NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 286, 288, pl. 52, figs. 11-11b, 13 (only), 1914.

The last two whorls are usually brown, lined with white; banded with a white band at the edge of the periphery of the last whorl; embryonic whorls pointed and bicolored.

The last two whorls of the lectotype (pl. 4, fig. 5) are lined with white; penultimate vinaceous drab, last whorl vandyke brown and rood's brown, peripheral band white; lip and columella callus vinaceous buff. Length 18.4 mm., greater diameter 11.2 mm., spire height 9.3 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 6???: **Waialae**, Gulick. The race probably occurred at a low elevation in either **Waialae Nui** or **Waialae Iki Gulch** (fig. 3a, p. 29). Gulick also reports it from Wailupe, but this may be an error due to mixture of material from different localities. Lectotype in BM.

The usual form is sinistral (pl. 1, fig. 2); postembryonic whorls pale pinkish cinnamon, streaked with sorghum brown and pale mouse gray, last two whorls lined with pale pinkish cinnamon and white, peripheral band white; lip cinnamon; impressed sutural band cinnamon buff. Length 16.9 mm., greater diameter 11.0 mm., spire height 9.0 mm., number of whorls 6.

A dextral shell (pl. 4, fig. 6) has a light gray color pattern; postembryonic whorls pale smoke gray darkening to ecru drab on the last whorl, last whorl and a half lined and banded with white. Length 17.8 mm., greater diameter 11.3 mm., spire height 9.5 mm. A narrow dextral (pl. 4, fig. 6a) measures: Length 17.3 mm., greater diameter 10.5 mm., spire height 10.0 mm.; color pattern similar to plate 1, figure 2.

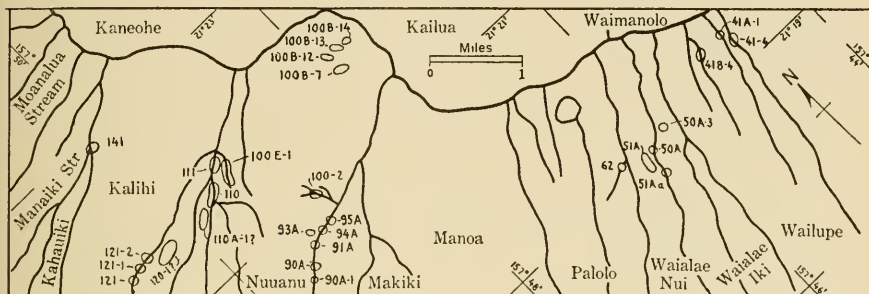


FIG. 3.—Eastern Oahu, leeward slope of the Koolau Range, including region I (fig. 7, p. 194), showing localities of subspecies of *A. apexfulva* belonging to the groups of *A. a. cestus* and *A. a. vittata*.

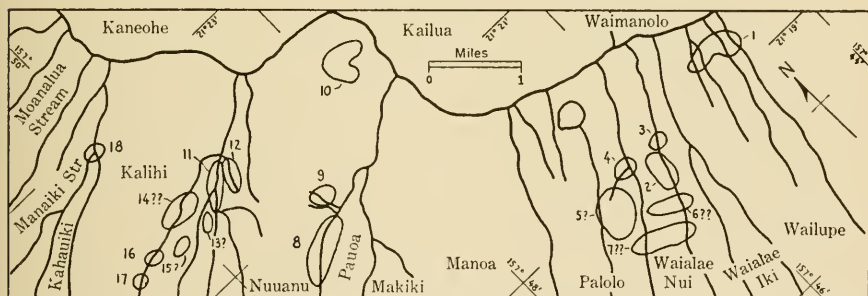


FIG. 3a.—Same as fig. 3, but exhibiting the area occupied by different subspecies of *A. apexfulva* belonging to the groups of *A. a. cestus* and *A. a. vittata*.

ACHATINELLA APEXFULVA WAIALAEENSIS, new subspecies

'PLATE I, FIGURE 3; PLATE 4, FIGURES 2-4

This race has a characteristic axially streaked color pattern, and lacks the spiral lines and bands of *A. a. forbesiana*, although it has the white peripheral band on the last whorl. *A. a. forbesiana* is an extinct race which probably existed at a low elevation immediately below the area occupied by *A. a. waialaeensis*.

The holotype of *A. a. waialaeensis* (pl. 1, fig. 3) has the first fourth postembryonic whorl mikado brown, remainder of the first

postembryonic whorl and penultimate whorl drab gray axially streaked with benzo brown, the first half of the last whorl is drab axially streaked with bone brown, tinted below the tawny impressed sutural band with tawny, last half whorl changes from drab to tawny axially streaked with bone brown, peripheral band white; lip and columella callus army brown. Length 18.8 mm., greater diameter 11.5 mm., spire 10.5 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 2: **Waialae Iki-Waialae Nui Ridge**, type locality 51Aa, elevation 1,250-1,350 feet, Meinecke, 1933; also 51A*, elevation 1,000-1,350 feet, Meinecke, 6 sinistral 1926, 1 sinistral 1928; **Waialae Nui Gulch**, locality 50A*, elevation 1,400-1,450 feet, Meinecke 1926, 1 sinistral 1929. Also collected in the region of **Waialae Iki-Waialae Nui Ridge** by O. H. Emerson, BBM 103924, 1916, BBM 103926, 7 sinistral 1918; **Waialae**, Wailupe, Gulick.

Area 3: **Waialae Iki-Waialae Nui Ridge**, locality 50A-3, elevation 1,500-1,650 feet, O. H. Emerson, BBM 167275-167276, 6 sinistral 1937 (figs. 3, 3a, p. 29).

The lightest color pattern (pl. 4, fig. 2) is gray; postembryonic whorls pale ecru drab streaked with drab gray and ecru drab, tinted on the last half whorl with sayal brown, and streaked with verona brown, impressed sutural band mikado brown.

Plate 4, figures 2a and 3, show reddish-brown patterns of this race which are peculiar to the shells of Waialae. The shell of figure 2a has dark vinaceous brown postembryonic whorls streaked with drab gray or deep olive buff. That of figure 3 has mikado brown postembryonic whorls darkening to cameo brown on the last whorl, at the edge of the periphery a band of cinnamon buff.

In locality 50A-3 only dextrals occur. The typical form (pl. 4, fig. 4) has the last two postembryonic whorls pinkish buff axially streaked with saccardo's umber and sepia, last half whorl snuff brown. Length 18.2 mm., greater diameter 12.0 mm., spire height 9.6 mm.

ACHATINELLA APEXFULVA MURICOLOR, new subspecies

PLATE 1, FIGURE 1; PLATE 4, FIGURES 1-1b

Achatinella cestus NEWCOMB, Pilsbry and Cooke, *Man. Conch.*, vol. 22, p. 288, pl. 52, figs. 9, 9a, 10 (only), 1914.

The shell resembles *A. a. waialaensis* but differs in having the dominant pattern always profusely lined with white over a gray ground. No reddish-brown color forms occur in this race and the characteristic white peripheral band is usually lacking, but may be present.

The postembryonic whorls of the holotype (pl. 1, fig. 1) are drab gray shading to drab, axially streaked on the last two whorls with snuff brown and bister, spirally lined with white; impressed sutural band cinnamon; lip and columella callus fawn color. Length 17.3 mm., greater diameter 11.1 mm., spire height 9.3 mm., number of whorls 6.

Distribution, area 1: **Niu-Wailupe Ridge**, type locality 41-4*, elevation 1,650-1,750 feet, Meinecke, BBM 120184, 120177, 1926, also BBM 120197, 6 sinistral 1931; **Kului-Laulaupoe Ridge, Wailupe**, locality 41A-1*, elevation 1,800-2,000 feet, Meinecke, BBM 120216-120217, 1926; **Laulaupoe-Wailupe Ridge, Wailupe**, 41B-4*, elevation 1,950-2,000 feet, Meinecke, BBM 120225, 1926 (figs. 3, 3a, p. 29).

The lightest color form of the shell (pl. 4, fig. 1) has the postembryonic whorls pale drab gray axially streaked with light drab; impressed sutural band pale pinkish cinnamon streaked with light pinkish cinnamon; last whorl lined with white. This color pattern resembles the light color pattern of *A. a. zwaialaensis* (pl. 4, fig. 2), but *muricolor* is definitely more lined and lacks the strong white peripheral band. An obese shell (pl. 4, fig. 1a) measures: Length 17.3 mm., greater diameter 11.8 mm., spire height 8.6 mm.; the postembryonic whorls strongly lined, last two whorls tulle buff lined and banded with wood brown, natal brown, snuff brown, and bister, peripheral band white; lip and columella callus wood brown.

A rare dark color pattern (pl. 4, fig. 1b) occurs on 7 specimens out of a total of 194 taken at various times from locality 41-4. The last two whorls are drab lightly axially streaked with vinaceous and sepia, faintly lined with pale pinkish buff.

ACHATINELLA APEXFULVA CESTUS Newcomb

PLATE 1, FIGURE 5; PLATE 4, FIGURES 9-11

Achatinella cestus NEWCOMB, Proc. Zool. Soc. London, 1853, p. 132, pl. 22, fig. 8.—PILSBRY and COOKE, Man. Conch., vol. 22, p. 286, pl. 29, fig. 8; pl. 55, fig. 1 (only), 1914.

This form is characterized by having a light yellowish-white ground splotched or rarely banded on the last two whorls above the periphery with reddish brown, and by having a dark reddish-brown band below the periphery; the base may be banded or splotched with reddish brown.

The lectotype (pl. 4, fig. 9) is marked with an "x" by me. The last two whorls are white streaked with splotches of walnut brown and

chocolate, below the periphery a band of chocolate and a band of white; lip and columella callus light brownish vinaceous. Length 17.7 mm., greater diameter 11.6 mm., spire height 9.6 mm., number of whorls 6.

Distribution, area 5?: Palolo, Gulick; Waiomao Stream, Palolo, Spalding, somewhere in the region of area 5? (figs. 3, 3a, p. 29). Gulick also reports specimens from Wailupe and Waialae, but I believe these are errors due to a mixture, because the known highland forms of this group from Waialae have distinctly different patterns from those of Palolo, and the lowland forms, if not extinct today, most probably would show a similar variation. Also collected by D. D. Baldwin, BBM 54741. Lectotype BM.

The Spalding lot contains only specimens of *A. a. cestus* and no specimens of *A. a. fuscostriata*, with which form *A. a. cestus* is always mixed in the Gulick collection. Pilsbry (Pilsbry and Cooke, 1912-1914, p. 287) mentions the fact that the Spalding lot contains dextral specimens of *A. a. simulator* which are undoubtedly *A. a. simulator* var. 1 of area 4. Judging from the data at hand, I believe that *cestus* is a distinct race from *A. a. fuscostriata* and probably grades into the higher race of *A. a. simulator* var. 1.

Specimen A of the BM type lot (pl. 4, fig. 10) has the white ground of the last whorl above the periphery streaked with zigzag lines and axial streaks of chocolate, below the periphery banded with chocolate and white.

In one BBM lot labeled Wailupe (pl. 4, fig. 11) a light color pattern has the postembryonic whorls pale pinkish cinnamon, lightly streaked with avellaneous, below the periphery of the last whorl a band of russet and a band of buckthorn brown.

A sinistral (pl. 1, fig. 5) resembles the lectotype; postembryonic whorls pale pinkish buff, splotched and streaked with russet, at the edge of the periphery a band of white, below the periphery a band of russet, a band of white, and a line of tawny.

ACHATINELLA APEXFULVA FUSCOSTRIATA, new subspecies

PLATE 1, FIGURE 4; PLATE 4, FIGURES 7, 7a

Achatinella cestus NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 287, 288, pl. 52, figs. 12, 12a, 13a, 14, 14a (only), 1914.

This extinct form resembles *A. a. cestus* but differs in not having the characteristic dark reddish-brown subperipheral band. The ground color is usually darker, being a yellowish cream instead of the white or whitish cream color of *A. a. cestus*. Both forms have a

zigzag pattern and probably came from adjacent areas. Possibly *fuscostriata* came from some area below *A. a. cestus* in Palolo or Waialae Nui somewhere in the region of area 7???

The postembryonic whorls of the holotype (pl. 1, fig. 4) are pinkish buff axially streaked with straight and zigzag lines of russet, last whorl with a white peripheral band, base banded with white and carob brown; lip and columella callus avellaneous. Length 16.4 mm., greater diameter 11.2 mm., spire height 8.4 mm., number of whorls 6.

Distribution, area 7???: Type locality **Palolo**, Gulick; also **Waialae**, Wailupe, Gulick (fig. 3a, p. 29). So much of the Gulick material is undoubtedly mixed from several valleys that the true distribution of the lowland races of *Achatinella* cannot be worked out from his data, if all his labels are considered correct. I do not believe this form ever occurred in Wailupe.

The color pattern may lack a white peripheral band on the last whorl (pl. 4, fig. 7), postembryonic whorls pale pinkish buff streaked with cinnamon, base banded with white. A dextral specimen (pl. 4, fig. 7a) has the postembryonic whorls cream buff, axially streaked with cinnamon, the last whorl banded above and below the edge of the periphery with a band made up of broken lines of cinnamon, basal band white and pinkish cinnamon.

ACHATINELLA APEXFULVA INNOTABILIS Smith

PLATE 4, FIGURE 8

Apex innotabilis SMITH, Proc. Zool. Soc. London, 1873, p. 78, pl. 9, fig. 23 (not fig. 19).

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 309, pl. 59, fig. 7 (only), 1914.

The holotype in the British Museum is marked with a red spot of sealing wax. The embryonic whorls are similar to *A. a. cestus*; postembryonic whorls are light pinkish cinnamon axially streaked with a darker shade of the ground color, peripheral band pale pinkish buff; lip pale pinkish buff; columella callus white. Length 18.1 mm., greater diameter 12.0 mm., spire height 10.6 mm., number of whorls 6.

This color form is undoubtedly a distinct race which is now extinct. Specimens of *A. a. innotabilis* are rare and are found only in collections made prior to 1900. The form is closest to that of *A. a. fuscostriata*. It was possibly a lowland race occurring below or near *fuscostriata*. *A. a. fuscostriata* may be an intermediate race between *A. a. innotabilis* and *A. a. cestus*. *A. a. innotabilis* possibly occurred in Wailupe.

ACHATINELLA APEXFULVA SIMULATOR Pilsbry and Cooke

PLATE I, FIGURE 6; PLATE 4, FIGURES 12-13a

Achatinella cestus color form *simulator* PILSBRY and COOKE, Man. Conch., vol. 22, p. 287, pl. 55, figs. 2, 3, 4, 1914.

The holotype of *A. a. simulator* selected by Pilsbry and myself is figured in the Manual of Conchology (pl. 55, fig. 2) and illustrated in this paper on plate 4, figure 12. The postembryonic whorls are white lined with chocolate except for a line of pecan brown on the last whorl below the suture; sutural band white. Length 17.8 mm., greater diameter 12.2 mm., number of whorls 6.

Distribution, area?: **Palolo**, Gulick. Pilsbry (Pilsbry and Cooke, 1912-1914, p. 287), says: "A small lot; No. 42 coll. Irwin Spalding, consists of dextral shells which occurred with the typical color form of *cestus*." This form is not typical *simulator* but is what I consider to be *A. a. simulator* var. 1. Typical *simulator* is a lowland race now extinct.

The color pattern of the holotype is a rare one occurring on only one specimen in the Gulick lots in the Bishop Museum. The usual color pattern and form of the shell (pl. 1, fig. 6) has white postembryonic whorls, lined on the last whorl with pinkish cinnamon, about the base a band of cinnamon; lip pale cinnamon pink slightly corrugated or roughened. Length 17.4 mm., greater diameter 11.5 mm., spire height 9.2 mm., number of whorls 6.

The shell may be more obese (pl. 4, fig. 13), length 17.2 mm., greater diameter 12.3 mm., spire height 8.5 mm., last whorl lined with cinnamon about the periphery, and army brown about the base. Dextral forms were also found by Gulick. A dextral specimen is figured on plate 4, figure 13a.

ACHATINELLA APEXFULVA SIMULATOR var. 1

PLATE I, FIGURE 7

Area 4: **Waiomao Stream, Palolo**, locality 62, elevation 1,250-1,350 feet, Meinecke, 8 dextral 1933, and 13 dextral 1914 (figs. 3, 3a, p. 29).

The shell is very close to *A. a. simulator* and differs only in the arrangement of the bands. Typical *A. a. simulator* always has a line or band at the edge of the periphery, and the bands and lines are never broken by axial streaks of a lighter color. The typical form of this variety (pl. 1, fig. 7) has white postembryonic whorls, last whorl above the periphery with a faint band of tilleul buff, below the periphery the last whorl banded with mikado brown, which bands

are streaked with white, in the umbilical region a band of Naples yellow; lip and columella callus light vinaceous fawn. Length 17.0 mm., greater diameter 11.8 mm., spire height 9.2 mm., number of whorls 6.

ACHATINELLA APEXFULVA BUENA, new subspecies

PLATE I, FIGURE 8; PLATE 4, FIGURES 14, 14a

The shell is small, sinistral, and seems to be closest in form to *A. a. simulator* but may be a race which occurred near *A. a. hanleyana*. The yellow-banded embryonic whorls are different from anything known from the region of Wailupe to Kalihi Valleys. However, because of the darkened embryonic whorls and the small size of the shells, this distinct color form is placed under the subspecific group of *A. a. cestus*. The first embryonic whorl of the holotype (pl. 1, fig. 8) is army brown, next whorl, upper eighth white, lower seven-eighths shades from avellaneous to chamois, last embryonic whorl, upper half white, lower half chamois; postembryonic whorls white banded just above the edge of the periphery with a band of russet flecked with light buff, on last whorl suprapерipheral band not so intense, having more streaks and flecks of light buff in it, peripheral band white except for a line of tawny on the lower portion of the band, base tawny axially streaked with light buff, with a line of white and a band of cream color in the umbilical region; lip and columella callus vinaceous buff. Length 16.4 mm., greater diameter 10.6 mm., spire height 8.8 mm., number of whorls $5\frac{3}{4}$.

This subspecies has been named after Buena Blok, the wife of Arthur Blok, of London, an ardent student of conchology.

Distribution, area?: **Nuuanu, west side, J. S. Emerson, BBM 102185, 33302.**

This form appears in the Gulick collection in several lots. In one lot from Palolo one specimen is found mixed with *A. a. simulator*. Gulick has another lot labeled Waipio BBM 70382, and still another Kalaikoa BBM 106736. It is probable that the Emerson and Gulick shells all came from a single now extinct lowland locality, but the exact location is not known. Another specimen was obtained from A. Block, BBM 165793, and one from Sowerby and Fulton, BBM 165794.

A narrow specimen (pl. 4, fig. 14) measures: Length 16.6 mm., greater diameter 10.0 mm., spire height 8.9 mm.; the postembryonic whorls are more heavily banded than the type, the bands are wood brown flecked with vinaceous buff. A light color form (pl. 4, fig. 14a)

has the postembryonic whorls white, banded on the penultimate above the periphery with a narrow band of russet, last whorl lined just above the periphery with a line of tawny, below the periphery ground white tinted with cream color, base banded with tawny and lined with cream color.

ACHATINELLA APEXFULVA GLOBOSA Pfeiffer

PLATE I, FIGURE 12; PLATE 4, FIGURES 21-24

Achatinella globosa PFEIFFER, Proc. Zool. Soc. London, 1855, p. 7, pl. 30, fig. 25.
Achatinella vittata REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 289-291, pl. 30, fig. 25; pl. 57, fig. 2b (only), 1914.

The lectotype of *A. a. globosa* (pl. 4, fig. 21) in the British Museum is marked "x" by me and is a deformed specimen. There is a break in the shell at the second embryonic whorl, which accounts for the depressed spire. The last postembryonic whorl is abnormally rounded and enlarged; postembryonic whorls white lined with cinnamon buff, peripheral band cinnamon buff, subperipheral band white, basal band hazel. On the aperture side of the last whorl, below the periphery, there is another break in the shell which has been repaired by the animal, and the pattern is lacking on approximately 2 mm. of the shell. The shell is thin, sutural band white; the lip is little thickened and colored pale vinaceous drab; the columella callus white. Length 16.4 mm., greater diameter 12.8 mm., spire height 6.5 mm., number of whorls $5\frac{1}{2}$.

Specimen A of the type lot (pl. 4, fig. 22) more accurately represents the usual form of *A. a. globosa*. The postembryonic whorls white lined with pinkish buff, last whorl banded with pinkish buff, axially streaked with white, in the umbilical region a band of cinnamon buff, darkening near the edge of the lip to mikado brown. Length 16.8 mm., greater diameter 11.4 mm., number of whorls 6.

Distribution: Nuuanu, Gulick, Baldwin, BBM 11884, J. S. Emerson, BBM 102196; Kalihi, Gulick. Specimens also obtained by Welch in London from Blok and Fulton.

A. a. globosa is a distinct subspecies which differs from *vittata* in being a smaller shell, always dextral and having a different range of color patterns. It occurs mixed with *A. a. vittata* in the Gulick collections, and odd specimens identifiable as *globosa* are usually found with typical forms of *vittata* in other collections.

The type lot of *A. a. vittata*, consisting of three specimens, has two specimens which are color patterns of *A. a. globosa*. One of these marked A (pl. 4, fig. 23) is a light color pattern and a narrow form

of the shell. The postembryonic whorls are white lined and banded on the last whorl with hazel, in the umbilical region a patch of carob brown; lip and columella callus vinaceous buff. Length 17.7 mm., greater diameter 11.2 mm., number of whorls $5\frac{3}{4}$.

The other specimen B has the usual *A. a. globosa* pattern similar to plate 1, figure 12. The type lot of three shells of *A. a. globosa* has one specimen marked B which is a typical *A. a. vittata*.

The usual form of the shell and color pattern of *A. a. globosa* in the Bishop Museum (pl. 1, fig. 12) has white postembryonic whorls banded and lined with hazel, base entirely hazel. Length 17.4 mm., greater diameter 11.7 mm., spire height 9.0 mm. A specimen from the Gulick collection (pl. 4, fig. 24) has white postembryonic whorls spirally banded with cinnamon buff, which darkens on the last eighth whorl to mikado brown; impressed sutural band cinnamon.

ACHATINELLA APEXFULVA HANLEYANA Pfeiffer

PLATE I, FIGURE 16; PLATE 4, FIGURES 25, 26

Achatinella hanleyana PFEIFFER, Proc. Zool. Soc. London, 1855, p. 202.

Achatinella lorata FÉRUSSAC, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 278, 281, 1914.

To quote from Pilsbry and Cooke:

Mr. Sykes remarks that this is "related to the form of *A. lorata* described as *A. nobilis*, and may prove to be an extreme variety." Dr. C. Montague Cooke, on examining the type in the British Museum considered it an artificially colored *lorata*.

The lectotype in the British Museum is not an artificially colored *lorata* but a normal shell which is a distinct subspecies and related to *A. a. globosa*. *A. a. hanleyana* closely resembles *A. a. globosa* in the shape of the bicolored embryonic whorls and in the size and color of the shell. *A. a. hanleyana*, however, is not banded with white but has a solid brown pattern above the periphery. No *A. a. lorata* has bicolored embryonic whorls similar to those of *A. a. globosa*. *A. a. hanleyana*, however, can easily be confused with brown forms of *Partulina radiata* Gould (see Pilsbry and Cooke, 1912-1914, p. 49, pl. 13, fig. 8). The two forms are so close that I have been in doubt as to whether or not to consider *hanleyana* a *Partulina*. However, I am inclined to believe that it is an extinct lowland *Achatinella*, because of its similarity to *A. a. globosa* and to a sinistral *Achatinella* (pl. 4, fig. 26) obtained by Dos Santos in Kalihi Valley, which has embryonic whorls very similar to those of *A. a. hanleyana* (pl. 1, fig. 16). *A. a. hanleyana*, moreover, has an impressed sutural band, a columella cal-

lus, and a rugose texture to the surface of the shell, not usual in specimens of *Partulina* from Oahu. *Partulina radiata* is placed by Pilsbry with *Partulinas* from the Island of Maui. In some collections the shells are labeled Maui. However, *radiata* is typically an Oahu shell and probably comes from the region of Nuuanu Valley.

The lectotype (pl. 4, fig. 25) has the first embryonic whorl colored terra cotta, next whorl upper half cartridge buff, lower half shades from terra cotta to pale vinaceous fawn and finally cartridge buff, remainder of the embryonic whorls cream buff; the first half post-embryonic whorl has the shell nacre worn off, remaining postembryonic whorls pinkish buff, axially streaked with close-set lines of hazel; lip and columella callus cartridge buff. Length 17.8 mm., greater diameter 12.0 mm., number of whorls 6. The surface of the shell does not seem smooth but slightly rugose as compared with *A. a. globosa*, but this rugosity of the surface may be an illusion caused by the axial streaking.

From Arthur Blok I obtained a specimen (pl. 1, fig. 16) which greatly resembles the holotype of *A. a. hanleyana* in form and color pattern. The postembryonic whorls ochraceous buff, axially streaked with tawny, subperipheral band ochraceous buff; the shell has a rugose appearance; impressed sutural band same as ground color of the shell. Length 19.1 mm., greater diameter 12.4 mm., spire height 9.9 mm.

In the Thurston collection a sinistral shell (pl. 4, fig. 26) collected by Dos Santos and reported from Kalihi has a ground color that matches that of *A. a. hanleyana*. The main difference is that the shell is heavily banded with dark bands. The postembryonic whorls are warm buff axially streaked with ochraceous tawny and banded with liver brown; lip and columella callus pale vinaceous fawn. This shell closely resembles the form of *A. a. simulans* var. 1 on the Kamaunaki-Kalihi Ridge. Probably it came from somewhere in the Kalihi region at a similar elevation, possibly on the north side of the valley. This sinistral shell may come from a colony of pure sinistral *hanleyana* of which this is the dark color form. The dextral race is probably from a colony of still lower elevation occurring directly below the sinistrals.

ACHATINELLA APEXFULVA HANLEYANA var. 1

PLATE I, FIGURE 17; PLATE 4, FIGURE 32

A peculiar form of *Achatinella apexfulva* was procured from Sowerby and Fulton in London. The shells were accompanied by no

data concerning their locality, but the fact that they have pointed *globosa*-like embryonic whorls leads me to believe that they are a lowland form of *hanleyana* which comes from somewhere in the general region of Nuuanu to Kalihi. However, I may be wrong in this belief and the shells may be lowland forms of *Partulina radiata* Gould. The first embryonic whorl (pl. 1, fig. 17) is fawn color, next whorl pale pinkish cinnamon, shading to pinkish buff; postembryonic whorls pinkish buff, axially streaked with mikado brown and spirally lined on the last whorl above the periphery with pinkish buff; impressed sutural band the ground color; columella callus white; lip tilleul buff. Length 20.8 mm., greater diameter 12.5 mm., spire height 10.8 mm., number of whorls 6½.

The shell may have a darker pattern (pl. 4, fig. 32). Postembryonic whorls clay color, axially streaked with mikado brown, spirally lined with cinnamon buff, last whorl below the periphery with a band of white, about the base a band of cream color; lip outer edge pinkish buff; columella callus and inner edge of lip white. Length 19.9 mm., greater diameter 12.6 mm., spire height 9.8 mm.

ACHATINELLA APEXFULVA SIMULANS Reeve

PLATE 1, FIGURE 19; PLATE 4, FIGURES 33-35a

Achatinella simulans REEVE, Conch. Icon., vol. 6, pl. 2, fig. 15, April 1850.

Achatinella vittata simulans REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, p. 292, pl. 57, fig. 8 (figs. 9-11, 14a, pl. 57, not *A. simulans* of Reeve 1850, but *A. a. rubidipicta*, new subspecies), 1914.

The shell is a small lowland form, with a dark brownish band in the umbilical region, one at or just below the edge of the periphery, one just below the periphery; above the periphery on the last whorl just behind the edge of the lip a patch of brown or group of brown lines.

The type lot of *A. a. simulans* contains three specimens none of which agree with Reeve's original figure (pl. 4, fig. 33). One specimen (pl. 4, fig. 34) in the type lot approaches the color pattern of the original figure and is considered the lectotype. It differs from the original figure in having a flat columella callus and in not having a subsutural band on the last two whorls and three dark chocolate sub-peripheral bands. The embryonic whorls are bicolored similar to those of *A. a. globosa*, first embryonic whorl deep mouse gray, later embryonic whorls white; postembryonic whorls white with a band of cinnamon just above or at the edge of the periphery, above the periphery on the last whorl just behind the edge of the lip a streak or patch of mikado brown, below the edge of the periphery a band of

warm sepia about the base, surface rough and pitted; impressed sutural band white; lip and columella callus cartridge buff. Length 18.5 mm., greater diameter 13.2 mm., number of whorls $5\frac{3}{4}$.

Distribution, area 16: **Kamanaiki-Kalihi Ridge**, locality 121-2, elevation 1,300-1,350 feet, H. Lemke and H. Lemke, Jr., 1934, BBM 114979, HL 128 (figs. 3, 3a, p. 29); **Kalihi**, Gulick, BBM 70464, Wilder, BBM 50544. Lectotype specimen "x" type lot BM marked by me.

Until shells were found in area 16, the only region containing shells similar to *A. a. simulans* was that of area 11. However, no white specimen in area 11 is found having a dark band about the umbilicus plus dark bands on the last whorl similar in arrangement to those on either the lectotype or the original figure. What Reeve called *A. decora* closely matches a color pattern of *A. a. rubidipicta* (area 11).

Plate 1, figure 19, shows the usual form of the shell in the Lemke lot from area 16, and a color pattern close to that of figure 34; the postembryonic whorls white, last whorl just below the impressed sutural band and below the periphery lined with cinnamon, basal band in the umbilical region sayal brown. Length 18.0 mm., greater diameter 11.7 mm., spire height 9.4 mm., number of whorls $6\frac{1}{4}$.

An obese specimen (pl. 4, fig. 35) looks more like the form of figure 34; the postembryonic whorls white, banded on the first postembryonic whorl with cinnamon, on the penultimate and last whorl lined with chocolate, last whorl below the periphery with a line of chocolate, two lines of clay color, a line of chocolate, and a band of chocolate in the umbilical region. Length 18.7 mm., greater diameter 12.3 mm., spire height 9.6 mm. One specimen (pl. 4, fig. 35a) has the last two whorls colored pale pinkish buff streaked with cinnamon buff and clay color and spirally lined with verona brown and warm sepia.

The color patterns of figures 35 and 35a indicate that yellow forms may occur at higher elevations. Quite possibly *A. a. simulans* is an intermediate race between a form of *A. a. albofasciata* and the lower form of *A. a. simulans* var. 1.

ACHATINELLA APEXFULVA SIMULANS var. 1

PLATE 1, FIGURE 20; PLATE 4, FIGURES 36, 36a

Area 17: **Kamanaiki-Kalihi Ridge**, locality 121, elevation 1,300-1,350 feet, Lemke and Lemke, Jr., 1934, BBM 114976, HL 127; 121-1, elevation 1,300 feet, Anderson and Kondo, 6 sinistral 1935 (figs. 3, 3a, p. 29).

The color patterns of area 17 tend to be darker than those of *A. a. simulans*, although individual shells in both areas 16 and 17 may have very similar patterns. A shell with the usual form and color pattern of the shell (pl. 1, fig. 20) has the postembryonic whorls white, banded with warm blackish brown, last whorl lined and tinted above the periphery with cinnamon buff, and a line of cinnamon buff on the white subperipheral band, about the umbilicus a band of cream color; lip and columella callus white, tinted with pale vinaceous fawn. Length 17.6 mm., greater diameter 12.0 mm., spire height 9.1 mm., number of whorls $6\frac{1}{4}$.

Another specimen (pl. 4, fig. 36) has the usual form and a light color pattern of the shell; postembryonic whorls white, lined with cinnamon buff and cinnamon; impressed sutural band white, on the penultimate whorl, just above the suture of the whorl below, a line of warm sepia, last whorl lined at the edge of the periphery with warm sepia, base banded with carob brown and a band of black in the umbilical region; lip and columella callus white, streaked with pale brownish vinaceous. Length 17.7 mm., greater diameter 12.3 mm., spire height 9.0 mm. This specimen of figure 36 resembles Reeve's original figure of *A. a. simulans*. The darkest color pattern (pl. 4, fig. 36a) is a warm blackish brown on the postembryonic whorls, last whorl banded at the periphery with a band of white which is lined with two lines of mikado brown, below the periphery a line of cinnamon buff; impressed sutural band sayal brown shading to pale pinkish buff at the upper edge.

ACHATINELLA APEXFULVA SIMULANS var. 2

PLATE I, FIGURE 23; PLATE 5, FIGURES 5-5b

Area 19: **Manaiki-Moanalua Ridge**, locality 151B*, elevation 1,400-2,150 feet, Meinecke, 1932, also collected by O. H. Emerson, BBM 103963, A. MacAuley, in J. S. Emerson collection, BBM 102208, Thurston, BBM 131112.

Area 19A: **Moanalua Stream**, locality 150B-2, elevation 900 feet, Welch and W. Giffard, 1935 (figs. 4, 4a, p. 53).

The usual form of the shell (pl. 1, fig. 23) in area 19 has the postembryonic whorls white, lined with tawny, with a patch of close-set ochraceous tawny lines on the first half postembryonic whorl; impressed sutural band tawny; peripheral and basal bands mars brown or chocolate, with the bands in the umbilical region seal brown or black; lip and columella callus light vinaceous fawn. Length 18.5 mm., greater diameter 12.3 mm., spire height 9.9 mm., number of whorls $6\frac{1}{4}$.

The shell may lack the dark chocolate bands (pl. 5, fig. 5) and have the last two postembryonic whorls white, lined with pinkish buff above the periphery, at and below the periphery with sayal brown, base tinted with cream color. The postembryonic whorls may be almost entirely white (pl. 5, fig. 5*a*) except for a patch of sayal brown on the impressed sutural band on the first and fourth postembryonic whorl, and a band and a line of ochraceous tawny on the base. A yellowish pattern (pl. 5, fig. 5*b*) is very much like the yellowish pattern of *A. a. simulans* (pl. 4, fig. 35*a*), and also that of *A. a. rubidipicta* (pl. 5, fig. 2*d*), postembryonic whorls pinkish buff, lined and banded with ochraceous tawny and tawny, about the periphery and below the ground is white, banded below the periphery with russet deepening to chocolate on the last half whorl.

This race has been considered a variety of *A. a. simulans* because of its small size and similarity in form. In a fossil bed, locality 150B-2, a few specimens of *apexfulva* are found and may be considered the extreme limit of this race of *simulans* var. 2, although it is probable that, were there more specimens obtainable retaining a sufficient amount of the color pattern, it might prove to be another variety.

GROUP OF *A. A. VITTATA* REEVE

ACHATINELLA APEXFULVA VITTATA Reeve

PLATE I, FIGURE 13; PLATE 4, FIGURES 17-20*b*

Achatinella vittata REEVE, Conch. Icon., vol. 6, pl. 2, fig. 9, April 1850.—PILSBRY and COOKE, Mar. Conch., vol. 22, p. 289, pl. 57, figs. 1, 2, 2*a*, 2*c* (only), 1914.

The holotype of *A. a. vittata* in the British Museum has a spot of red sealing wax on the aperture side of the shell (pl. 4, fig. 17). Postembryonic whorls white, penultimate banded with avellaneous, last whorl above the periphery with two bands of avellaneous and a subperipheral band of pinkish buff, below the periphery banded and lined with fawn color, and a band of army brown in the umbilical region; lip and columella callus pale vinaceous fawn. Length 19.0 mm., greater diameter 12.7 mm., spire height 10.0 mm., number of whorls 6.

Distribution, area 12: **Nuuanu**, Gulick; **Hillerbrand's Glen**, **Nuuanu**, locality 100E-1*, elevation 1,000-1,500 feet, R. A. Cooke, BBM 58284, and C. M. Cooke, BBM 22119, 19916 (figs. 3, 3*a*, p. 29). Dr. C. M. Cooke tells me that these shells come from somewhere along the ridge on which locality 100E-1* is plotted. They were probably collected on the lower portion of the ridge at an elevation of around 1,000-1,500 feet, because Meinecke reports the larger race of *A. a.*

rubidipicta near the head of this subridge on the Nuuanu-Kapalama Ridge. Further collecting will establish the exact location of this race.

The specimens of *A. a. vittata* from Nuuanu collected by Gulick closely match the holotype. The shells may be dextral or sinistral. A sinistral specimen (pl. 1, fig. 13), is very similar to the color pattern of the type; postembryonic whorls white, lined and streaked with cinnamon buff or pinkish buff and lined with mikado brown. A darker color pattern (pl. 4, fig. 18) has the penultimate whorl banded with pinkish buff shading to avellaneous and fawn color on the last whorl; impressed sutural band and subsutural band pale pinkish buff.

The R. A. Cooke and C. M. Cooke, Jr., lots are not typical *vittata* but contain patterns similar to those of typical *vittata*. The locality is a wide one and probably represents a mixture of typical *vittata* with typical *rubidipicta* patterns. In the C. M. Cooke lot, which may represent a collection of shells taken mostly from the lower portion of locality 100E-1*, 36 percent of the shells have a pattern similar to that of plate 4, figure 19, penultimate whorl light buff banded with white, the last whorl banded with white below the subsutural band of light buff, at and below the periphery banded and lined with ochraceous tawny and tawny axially streaked with light buff, base banded with white, and lined and banded with mars brown. A rare brown pattern (pl. 4, fig. 19a) has the last whorl and a half colored light buff below the suture, just above and below the periphery the ground is axially streaked and banded and tinted with tawny and russet.

In the R. A. Cooke lot color patterns are closer to *A. a. rubidipicta* and probably come from a region adjacent to area 11. The typical form and color pattern of the shell in the R. A. Cooke lots (pl. 4, fig. 20) has the penultimate whorl white, lined with cinnamon buff, impressed sutural band cinnamon, last whorl above the periphery pale pinkish buff lined with pinkish buff and verona brown, edge of the periphery banded with vandyke brown and a band of white, subperipheral band vandyke brown, remainder of the base white, sutural band pinkish cinnamon. Length 18.7 mm., greater diameter 13.0 mm., spire height 9.5 mm. The shell may have an entirely white ground (pl. 4, fig. 20a), the last whorl profusely lined with walnut brown and chocolate; impressed sutural and subsutural bands light buff. A dark color pattern (pl. 4, fig. 20b) has the penultimate whorl warm buff, banded and streaked with ochraceous tawny on the upper

half of the whorl, including the impressed sutural band, lower half mars brown, last whorl the impressed sutural and subsutural bands ochraceous tawny, remainder of the whorl carob brown, lined with white.

ACHATINELLA APEXFULVA VITTATA var. 1

PLATE 1, FIGURE 9; PLATE 4, FIGURES 15-15b

Achatinella vittata REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, p. 290, pl. 57, figs. 3-3b (only), 1914.

Area 8: **Pauoa-Nuuanu Ridge**, locality 91A*, elevation 1,500-1,800 feet, Meinecke, 1923, 1925, 1926, 4 sinistral 1931. Also locality 90A*, elevation 1,400-1,450 feet, Meinecke, 1922; 90A-1*, elevation 1,400 feet, Lemke, 1932; 93A*, elevation 1,500-1,800 feet, 7 sinistral 1928; 94A*, elevation 1,700 feet, 1927, 1928, 1931; 95A*, elevation 1,750 feet, Meinecke, 1927, 1931 (figs. 3, 3a, p. 29). Other collectors are J. S. Emerson, BBM 102189, E. D. Baldwin, BBM 56644-56646, Wilder, BBM 50498, Thurston shells collected by Dos Santos, BBM 131084, A. F. Judd, BBM 110294-110299.

The usual form of the shell is darker than *A. a. vittata*, both in the shade of yellow on the early postembryonic whorls and in the reddish-brown banding on the last whorl. Large series of shells of *A. a. vittata* and *A. a. vittata* var. 1 are separable, but individual specimens from each race are indistinguishable. The usual form of *vittata* var. 1 (pl. 1, fig. 9) has the first half postembryonic whorl white axially streaked with cinnamon buff, penultimate whorl white axially streaked with cinnamon buff, spirally banded with dark vinaceous brown and white, last whorl banded and lined with white and dark vinaceous drab, below the periphery lines of dark vinaceous brown; impressed sutural band shades from tawny, on the first whorl, to cinnamon on the last; subsutural band on the last whorl also cinnamon; lip and columella callus vinaceous fawn. Length 18.8 mm., greater diameter 12.5 mm., spire height 9.5 mm., number of whorls 6.

An elongate specimen (pl. 4, fig. 15) measures: Length 18.6 mm., greater diameter 11.6 mm., spire height 10.5 mm.; first postembryonic whorl and penultimate whorl, white faintly tinted and axially streaked with pinkish buff and lined with cinnamon, last whorl above the periphery white, lined and streaked with pinkish buff, and a band of snuff brown above the periphery, peripheral band white with a line of chocolate at the upper margin of the band, below the periphery banded and lined with dark vinaceous brown; impressed sutural band changes from tawny to cream buff.

An obese shell (pl. 4, fig. 15*a*) shows the lightest color form of this race; postembryonic whorls white spirally lined with pinkish buff, below the periphery of the last whorl a faint line of verona brown, below which are faint bands of pinkish buff, on the last fourth whorl the bands are darker above and below the periphery, being warm sepia and mikado brown. Length 17.3 mm., greater diameter 12.7 mm., spire height 8.9 mm. The darkest color pattern (pl. 4, fig. 15*b*) has the postembryonic whorls light ochraceous buff, banded and axially streaked with hay's brown and sorghum brown, base lined with white. The color patterns of figures 15*a* and 15*b* are rare patterns occurring only on a few specimens in area 8.

ACHATINELLA APEXFULVA VITTATA var. 2

PLATE I, FIGURE 10; PLATE 4, FIGURES 16, 16*a*

Achatinella vittata REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, p. 290, pl. 57, figs. 4, 4*a*, 5-5*b* (only), 1914.

Area 9: **Glen Ada, Nuuanu**, locality 100-2*, approximate elevation 1,200-1,500 feet, R. A. Cooke, C. M. Cooke (figs. 3, 3*a*, p. 29).

While series of shells from area 9 are quite distinct from typical *A. a. vittata* or *A. a. vittata* var. 1, because of the dominance of light color patterns, nevertheless the color patterns of area 9 are repeated in other areas and mixed lots are difficult to separate.

The usual form of the shell (pl. 1, fig. 10) has white postembryonic whorls, banded on the last half of the penultimate with two bands of fawn color, last whorl above the periphery banded with two bands of cameo brown, lined below the suture with cinnamon buff, the lines being broken with axial streaks of white, subperipheral band cameo brown; sutural band cinnamon buff; lip and columella callus vinaceous buff. Length 18.9 mm., greater diameter 12.3 mm., spire height 9.9 mm., number of whorls 6.

The lightest color pattern (pl. 4, fig. 16) has white postembryonic whorls lined on the last whorl with walnut brown. An obese shell and a rare dark color pattern (pl. 4, fig. 16*a*), found on only 6 percent of the shells in the R. A. Cooke lot, has the postembryonic whorls white, last whorl above the periphery banded with pinkish buff axially streaked with cinnamon, banded at and below the periphery with chocolate; impressed sutural band shades from tawny to ochraceous tawny. Length 18.5 mm., greater diameter 12.8 mm., spire height 9.7 mm.

ACHATINELLA APEXFULVA CINEREA Sykes

PLATE 1, FIGURE 11; PLATE 4, FIGURE 37; PLATE 5, FIGURES 1, 1a

Achatinella vittata var. *cinerea* SYKES, Fauna Hawaiiensis, p. 305, 1900.*Achatinella vittata cinerea* SYKES, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 289, 291, pl. 57, figs. 6-7, 1914.

The holotype (pl. 4, fig. 37) has the first postembryonic whorl buckthorn brown, penultimate whorl banded with avellaneous, white, and dark olive buff, last whorl ground white banded with maroon or hay's maroon; impressed sutural band and subsutural band white; columella callus vinaceous fawn; lip vinaceous fawn banded with white. Length 18.7 mm., greater diameter 12.4 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 10: Nuuanu, locality 100B-7?, elevation 1,250-1,400 feet, Meinecke, 1911, 1914, 1916; 100B-12, elevation 1,150-1,250 feet; 100B-13, elevation 1,150-1,350 feet; 100B-14, elevation 1,250-1,500 feet, 1 sinistral, all collected by C. M. Cooke, Jr. (figs. 3, 3a, p. 29). The Meinecke locality may be wrongly plotted one ridge south of where it actually is, because Dr. Cooke, who carefully worked over this section of Nuuanu and made sketch maps of the region, does not report any *apexfulva* from the region of locality 100B-7? Other collectors of *A. a. cinerea* are Wilder, BBM 50504, R. A. Cooke, BBM 58138. Holotype in BM, collected in Nuuanu by Perkins.

The usual color pattern and form of the shell (pl. 1, fig. 11) has the first embryonic whorl warm sepia, next whorl upper fourth pale pinkish buff, remainder of the whorl shades from prout's brown to buckthorn brown, last embryonic whorl upper fourth white, lower three-fourths warm buff finely lined with white; first postembryonic whorl and first half of penultimate banded with a light shade of buckthorn brown and warm buff, last half of penultimate, and first half of last whorl above the periphery, drab gray, banded below the white sutural band, with a band of wood brown shading to chocolate, a band of white, and 2 bands of chocolate, last half of the last whorl chocolate, banded and lined with white, below the periphery last whorl white, banded with chocolate, in the umbilical region a patch of naples yellow, banded with chocolate. Length 19.1 mm., greater diameter 13.1 mm., spire height 9.3 mm., number of whorls 6.

The color pattern may be light gray (pl. 5, fig. 1); first post-embryonic whorl and first half of the penultimate white faintly tinted with pinkish buff, last whorl and a half shades from pale smoke gray to smoke gray on the last whorl, banded, lined, and finely axially streaked with white—the last half whorl is also lined above

the periphery with fawn color—below the periphery banded with a band of warm sepia lined with smoke gray, the aperture side of the last whorl has a line of warm sepia above the white basal band. An elongate specimen (pl. 5, fig. 1*a*), length 19.8 mm., greater diameter 12.8 mm., spire height 10.0 mm., shows the darkest color form, the last whorl banded with white and chocolate.

ACHATINELLA APEXFULVA ALBOFASCIATA Smith

PLATE I, FIGURE 14; PLATE 4, FIGURES 27-28*b*

Apex albofasciatus SMITH, Proc. Zool. Soc. London, 1873, p. 78, pl. 9, fig. 21.
Achatinella vittata simulans REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 292, 293, pl. 57, figs. 12, 13, 14*a*, 14*c* (only), 1914.

The holotype of *A. a. albofasciata* (pl. 4, fig. 27) in the British Museum is marked with a red dot of sealing wax. The postembryonic whorls are cinnamon buff darkening to sayal brown on the last half whorl, banded on the last whorl at the edge of the periphery with white and in the umbilical region with white and light pinkish cinnamon; impressed sutural band white; lip and columella callus pale pinkish buff. Length 18.5 mm., greater diameter 12.6, spire height 9.0 mm., number of whorls 5 $\frac{3}{4}$.

Distribution, area 13?: **Kapalama Stream**, locality 110A-1?, "N. Bank opposite Waiolani Peak. Halfway from top to bottom of Gulch, elevation 1,500-1,550, Herb. Alani [*Pelea*]," L. A. Thurston 1911, BBM 131103-131106 (figs. 3, 3*a*, p. 29). Also collected in **Kapalama** by W. D. Wilder, BBM 50543, D. Fraser, BBM 15838, and Dos Santos for Thurston, BBM 131095-131096.

The Thurston lots contain 37 dextrals and 4 sinistrals. The usual form of a dextral (pl. 1, fig. 14) has the last half of the first postembryonic whorl, and the first half of the penultimate whorl, pinkish buff axially streaked with cinnamon buff, last half of the penultimate pale pinkish buff banded with light pinkish buff, shading on the last whorl to pinkish buff finely lined and streaked with white or pale pinkish buff, at the edge of the periphery a wide band of white; impressed sutural band pinkish buff; lip light vinaceous fawn spotted with white. Length 19.8 mm., greater diameter 12.3 mm., spire height 10.8 mm., number of whorls 6 $\frac{1}{2}$. A sinistral specimen (pl. 4, fig. 28*b*) is very like the holotype, differing in being banded with white above the periphery and about the base, last two whorls with bands of cinnamon buff streaked with cinnamon. The Kapalama form of *A. a. albofasciata* is very close in form to *A. a. rubidipicta*. From Thurston's description it occupies an area just below *A. a. rubidipicta* (area 11). A few specimens of *A. a. albofasciata* are often found in lots

of *A. a. rubidipicta*, and probably come from the border region between areas 11 and 13.

The darkest color form of the shell is shown in plate 4, figure 28, the last two whorls are tawny axially streaked and lined with ochraceous buff, on the last whorl a wide band of white at the periphery. The lightest color pattern (pl. 4, fig. 28a) is entirely white on the last two whorls lined with ochraceous tawny.

ACHATINELLA APEXFULVA ALBOFASCIATA var. 1

PLATE 1, FIGURE 21; PLATE 4, FIGURES 29, 29a

Distribution, area 14??: **Kalihi**, J. S. Emerson collection, BBM 102205-102207, collected by Gomes and W. B. Olson. The exact position of the locality is unknown, but has been plotted by me on the Kamaikai-Kalihi Ridge opposite area 13? (fig. 3a, p. 29), because of the similarity of this form to *A. a. albofasciata*. This form should be collected again and the exact locality determined.

The shells have a lighter color pattern than *A. a. albofasciata*. The shade of the color pattern of the Kalihi shells best matches the holotype of *A. a. albofasciata*, but the banding of the Kapalama shells is closer to that of the holotype of *albofasciata* and for this reason Kapalama is considered the region of the type locality. The Kalihi shells are dominantly sinistral and composed of light color patterns. Forms similar to plate 4, figure 28, are not found in this Kalihi lot. Out of 34 shells, 9 are dextrals.

The typical form of the shell (pl. 1, fig. 21) is smaller than the usual form of *albofasciata* from Kapalama, the postembryonic whorls cinnamon buff faintly lined and streaked with white; impressed sutural band the color of the ground; last whorl below the edge of the periphery white, lined with cinnamon buff; lip and columella callus pale cinnamon pink. Length 18.1 mm., greater diameter 12.3 mm., spire height 9.7 mm., number of whorls 6.

The lightest color pattern (pl. 4, fig. 29) has the postembryonic whorls white, lined with cinnamon buff. The dextral form of the shell (pl. 4, fig. 29a) has the last two whorls light buff, axially streaked and lined with ochraceous buff, last whorl at the periphery and below the periphery banded with white. This form looks very much like yellow forms of *A. a. globosa* (pl. 4, fig. 24).

ACHATINELLA APEXFULVA OLIVERI, new subspecies

PLATE 1, FIGURE 18; PLATE 4, FIGURES 30-31

This form is intermediate between the more globose upper race of *A. a. albofasciata* and the smaller form of *A. a. simulans* var. 1.

The first postembryonic whorl of the holotype (pl. 1, fig. 18) is pale pinkish cinnamon spirally lined, banded, and tinted with sayal brown, last two whorls sayal brown, last whorl below the periphery banded and lined with white; impressed sutural band white; lip and columella callus light vinaceous fawn. Length 19.7 mm., greater diameter 12.5 mm., spire height 11.0 mm., number of whorls $6\frac{3}{4}$.

Distribution, area 15?: **Kamanaiki Stream**, type locality 120-1?, O. H. Emerson, BBM 103962; also collected by J. S. Emerson, BBM 102203-102204, Dos Santos, BBM 74301, and Thwing, BBM 28544-28546 (figs. 3, 3a, p. 29). The locality has not been found in recent years. Only an approximation has been made by Dr. C. M. Cooke, and Dr. Oliver Emerson which is somewhere in the vicinity of the locality. The shell is named after Dr. Oliver Emerson, who discovered it.

A dark white-lined color pattern (pl. 4, fig. 31) has the last two whorls banded with russet and lined with white. The darkest color pattern (pl. 4, fig. 30) has the last two whorls liver brown axially streaked with hazel, about the periphery of the last whorl a line of white; impressed sutural band white. The lightest color pattern (pl. 4, fig. 30a) is white, lined on the last two whorls with hazel. This pattern occurs on only one shell in the type lot.

ACHATINELLA APEXFULVA RUBIDIPICTA, new subspecies

PLATE 1, FIGURE 15; PLATE 5, FIGURES 2-2d

Achatinella vittata simulans REEVE, Pilsbry and Cooke, Man. Conch., vol. 22, p. 292, pl. 57, figs. 9-11, 14b (only), 1914 (not of Reeve 1850).

The shell is larger than *A. a. simulans*, having a characteristic smooth surface, and usually having spiral bands which are generally not broken by axial streaks. The form is closest to that of *A. a. cinerea*, having an inflated last whorl. The holotype (pl. 1, fig. 15) has the first half of the first embryonic whorl rood's brown, last half upper portion white, the lower half rood's brown changing to mouse gray on the next whorl, on the last half of the second embryonic whorl and on the remaining embryonic whorls the lower band is a faint shade of cream buff, upper band white; the postembryonic whorls white, the first half of the first postembryonic whorl banded on the lower fourth of the whorl with cinnamon buff, penultimate and last whorls lined with cinnamon, last half of penultimate and last whorl banded at the edge of the periphery with burnt umber, last whorl below the periphery with a line of burnt umber; lip and

columella callus pale vinaceous fawn. Length 19.5 mm., greater diameter 13.2 mm., spire height 10.2 mm., number of whorls 6 $\frac{3}{4}$.

Distribution, area 11: **Nuuanu-Kapalama Ridge**, type locality 110*, elevation 1,750-1,870 feet, Meinecke, 1921, 1922, 1927, 1929; also locality 111*, elevation 1,800-2,100 feet, Meinecke, 1 sinistral 1929 (figs. 3, 3a, p. 29).

The color pattern of 11 percent of the shells (pl. 5, fig. 2) is a more heavily lined one; the last two whorls may be white, lined and banded on the penultimate with mikado brown, on the last whorl banded with vandyke brown and lined with mikado brown, base banded with seal brown, umbilical region tinted with cream buff. Twenty-four percent are conspicuously banded; last two whorls white, (pl. 5, fig. 2a) banded with chocolate and lined on the penultimate with a subsutural band of mikado brown, which splits into two lines on the last half of the penultimate and fades out on the last half of the last whorl. The darkest color pattern and elongate form of the shell (pl. 5, fig. 2b), occurring on 2 percent of the shells, has the last two whorls burnt umber axially streaked with cinnamon and banded on the last whorl with white; impressed sutural band chocolate shading to cinnamon buff at the upper edge. Length 19.8 mm., greater diameter 12.8 mm., spire height 9.9 mm. This shell resembles the dark color pattern of *A. a. cinerea* (pl. 5, fig. 1a). The main difference is that *A. a. cinerea* has the embryonic whorls banded with yellow and the first two postembryonic whorls banded with yellow and gray. The obese form and lightest color pattern of the shell (pl. 5, fig. 2c) measures: Length 19.0 mm., greater diameter 13.8 mm., spire height 9.4 mm.; postembryonic whorls white, below the impressed sutural band a line of cinnamon deepening to warm sepia on the last whorl, the base lined and banded with chocolate. This white color pattern occurs on 20 percent of the shells. Eight percent have a yellow color pattern which looks like an intermediate form between *rubidipicta* and *albofasciata*. One of these (pl. 5, fig. 2d) has the last whorl and a half pale pinkish buff axially streaked and lined with cinnamon, banded with white at the edge of the periphery, below the periphery banded with amber brown, and a basal band of pinkish buff; impressed sutural band pinkish buff axially streaked with cinnamon. In some collections specimens of *A. a. albofasciata* are found mixed with lots of *A. a. rubidipicta*. The reason for this is that the shells were either collected in a locality intermediate between areas 11 and 13 or all the shells from areas 11 and 13 were lumped together in one locality.

ACHATINELLA APEXFULVA RUBIDIPICTA var. 1

PLATE 5, FIGURES 3-3b

Area?: **Kalihi**, Wilder, BBM 50544, 9 dextral, 16 sinistral.

The shells are similar to *A. a. rubidipicta* but have a different series of color patterns. Some dextral specimens have a color pattern which resembles *A. a. albofasciata* and differs only in having light reddish-brown bands instead of yellowish-brown ones. One of these distinctive color patterns (pl. 5, fig. 3) is a white shell banded and lined on the last two whorls with pecan brown, and a band of ochraceous tawny below the periphery. The usual form of a dextral shell (pl. 5, fig. 3a) measures: Length 19.7 mm., greater diameter 13.0 mm., spire height 10.0 mm.; last two postembryonic whorls white, with a band of russet below the white sutural band and just above the edge of the periphery, last whorl lined at the edge of the periphery with two lines of burnt umber, below the periphery lined and banded with burnt umber on the rest of the whorl. The sinistral form of the shell (pl. 5, fig. 3b) is very like typical *A. a. rubidipicta* but the distribution of the chocolate bands over the white ground on the last two whorls is different from anything found in locality 110.

ACHATINELLA APEXFULVA RUBIDIPICTA var. 2

PLATE 1, FIGURE 22

Area 18: **Kalihi-Kahauiki Ridge**, locality 141*, elevation 1,650 feet, Meinecke, 2 sinistrals 1927 (figs. 3, 3a, p. 29). Also collected in **Kahauiki** by Wilder, BBM 50519. The usual color pattern of the shells in the Wilder lot is similar to that of the two Meinecke shells, and they are believed to have come from the same locality.

The form is very close to *A. a. rubidipicta* but has a slightly different series of color patterns. The usual color pattern (pl. 1, fig. 22) has the last two postembryonic whorls white, lined below the suture with a line of mikado brown, last whorl banded with two chocolate bands. Length 19.8 mm., greater diameter 13.4 mm., spire height 10.2 mm. The color pattern may be lined similar to plate 5, figure 3b.

ACHATINELLA APEXFULVA RUBIDIPICTA var. 3

PLATE 5, FIGURES 4-4e

Area?: **Moanalua**, Wilder, BBM 50522.

The subspecies resembles *A. a. rubidipicta* but has a different series of color patterns. The embryonic whorls are similar to those of *A. a. simulans* var. 2, and are intermediate in form and color

pattern between *A. a. ozum* and *A. a. rubidipicta*. The shells probably came from above area 19 on the Manaiki-Moanalua Ridge.

The usual form of the shell and the color pattern of 52 percent of the specimens (pl. 5, fig. 4) has the postembryonic whorls white, lined with cinnamon and mikado brown, and banded with chocolate, last whorl subperipheral band white, below which is a line of cinnamon and cinnamon buff, base chocolate; impressed sutural band cinnamon; lip and columella callus light vinaceous fawn. Length 19.6 mm., greater diameter 13.0 mm., spire height 9.8 mm., number of whorls $6\frac{1}{2}$.

An elongate shell (pl. 5, fig. 4a) measures: Length 19.3 mm., greater diameter 12.5 mm., spire height 9.5 mm.; last two postembryonic whorls pale pinkish buff, profusely lined and banded with russet and mars brown, impressed sutural band cinnamon. An obese form of the shell (pl. 5, fig. 4b) with light color pattern found on 31 percent of the shells has the postembryonic whorls white, lined with pinkish buff; impressed sutural band pinkish buff; last whorl banded at the edge of the periphery with a band and below the periphery with bands and lines of chocolate. Length 19.1 mm., greater diameter 13.4 mm., spire height 9.1 mm.

Seven percent have a lined spiral pattern (pl. 5, fig. 4c); postembryonic whorls above the periphery lined with russet, peripheral band narrow, about 0.5 mm. instead of nearly 2 mm. as in figure 4, banded below and at the periphery with chocolate. The darkest pattern (pl. 5, fig. 4d) on 9 percent, is russet, streaked with cinnamon buff on the first half of the penultimate, last half of penultimate ochraceous tawny axially streaked with burnt umber, last whorl chocolate, axially streaked with ochraceous tawny. A single specimen (pl. 5, fig. 4e) has a white ground lined with warm buff; impressed sutural band ochraceous tawny fading to white on the last whorl. This pattern is very similar to lined patterns of *A. a. albofasciata*.

GROUP OF *A. a. PILSBRYI* NEW SUBSPECIES

***ACHATINELLA APEXFULVA* PILSBRYI, new subspecies**

PLATE I, FIGURE 29; PLATE 5, FIGURE 27

The holotype (pl. 1, fig. 29) is small, embryonic whorls white; spire pointed, postembryonic whorls white; impressed sutural band tawny; last whorl below and at the periphery banded with tawny and a basal band of kaiser brown; lip fawn color, tuberculate; columella callus white. Length 17.6 mm., greater diameter 12.4 mm., spire height 9.2 mm., number of whorls $6\frac{1}{2}$.

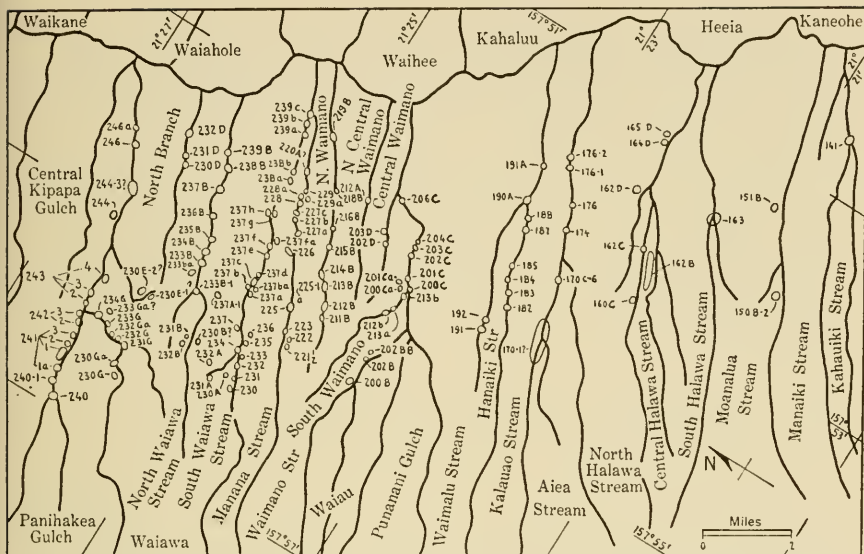


FIG. 4.—Southeast-central Oahu, leeward slope of the Koolau Range, including regions Ia, II, IIIa, half of region III, and two valleys of region I (fig. 7, p. 194), showing localities of subspecies of *A. apexfulva* belonging to the groups of *A. a. cestus*, *A. a. vittata*, *A. a. pilsbryi*, *A. a. turgida*, *A. a. polymorpha*, and *A. a. irwini*.

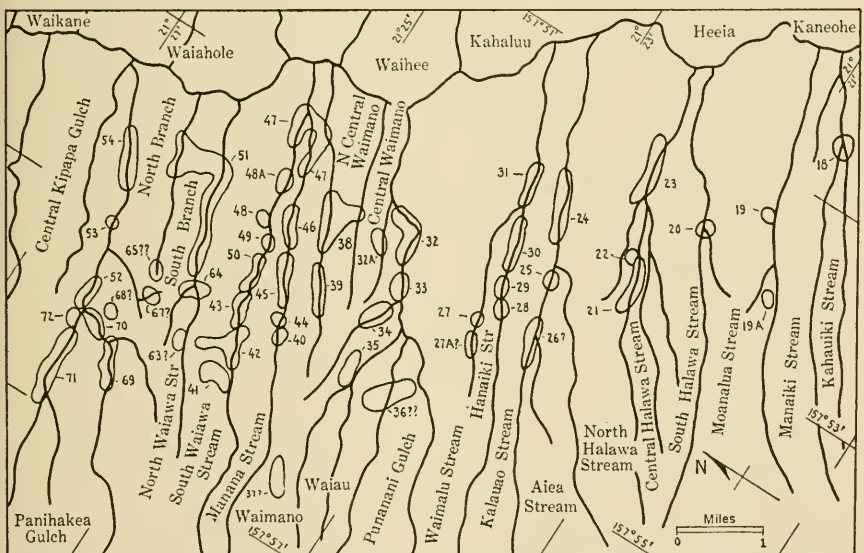


FIG. 4a.—Same as fig. 4, but showing the area occupied by different subspecies of *A. a. apexfulva* belonging to the groups of *A. a. cestus*, *A. a. vittata*, *A. a. pilsbryi*, *A. a. turgida*, *A. a. polymorpha*, and *A. a. irwini*.

Distribution probably somewhere in the region of area 26?: **Aiea-Kalauao Ridge**, approximate locality 170-1?, Judd, BBM 110210, and Cooke, BBM 72494 (figs. 4, 4a, p. 53). The subspecies is named after Dr. Henry A. Pilsbry. The shell has not been found in many years and may be extinct.

The form of a broadly banded juvenile shell (pl. 5, fig. 27) has an elongate spire. Length 16.9 mm., greater diameter 11.6 mm., spire height 9.0 mm. Postembryonic whorls white, banded with cinnamon, last whorl below the periphery cinnamon, lined with two lines of white and a line of mikado brown. The shell is a dead specimen and the color has faded.

ACHATINELLA APEXFULVA ROSEATA, new subspecies

PLATE I, FIGURE 39; PLATE 6, FIGURES 25-25b

The shell is a small fossil form which looks like *A. a. lilacea* from the region of North Kaukonahua Stream. The holotype (pl. 1, fig. 39) has white, pointed, embryonic whorls; postembryonic whorls pale vinaceous fawn axially streaked and faintly spirally lined with light vinaceous fawn and vinaceous fawn; impressed sutural band white or tinted pale pinkish buff; lip outer margin pinkish buff, inner margin pale pinkish buff. Length 17.5 mm., greater diameter 11.5 mm., spire height 9.6 mm., number of whorls 6½.

Distribution, area 37?: **Waimano Stream**. "Just below the bridge on the plantation R. R.," C. M. Cooke, BBM 40679-40680, also collected by Thaanum, BBM 40716-40717, and Wilder, BBM 51932. The shells were found in fossil state under a boulder in the bottom of the gulch. I have tentatively plotted the locality somewhere in the region of area 37? (fig. 4a, p. 53).

The holotype is a little smaller than usual. The usual form should be 18+mm., with a greater diameter of 11+mm., but no specimens with the usual form have the color sufficiently well preserved to be used for the holotype. The darkest color pattern (pl. 6, fig. 25) on a single specimen has the postembryonic whorls colored light vinaceous fawn axially streaked and lined with vinaceous fawn; impressed sutural band vinaceous buff; lip vinaceous buff. Length 19.1 mm., greater diameter 11.9 mm., spire height 11.2 mm.

The narrowest specimen (pl. 6, fig. 25a) measures: Length 18.1 mm., greater diameter 10.8 mm., spire height 11.0 mm. The typical sinistral form of the shell (pl. 6, fig. 25b) measures: Length 18.0 mm., greater diameter 11.7 mm., spire height 10.4 mm.

ACHATINELLA APEXFULVA LAURANI, new subspecies

PLATE I, FIGURES 37, 38; PLATE 5, FIGURES 28-31; PLATE 6, FIGURE 1

The embryonic whorls of the holotype (pl. 1, fig. 38) are white; first postembryonic and penultimate whorls, avellaneous, finely axially streaked with faint lines of bone brown, last whorl avellaneous axially streaked with olive brown and natal brown, spirally lined below the periphery with olive brown and cream buff, and banded with buffy brown, last eighth whorl bone brown; impressed sutural band natal brown; outer margin of the lip natal brown, inner margin fawn color. Length 18.2 mm., greater diameter 12.4 mm., spire height 9.7 mm., number of whorls $6\frac{5}{8}$.

Distribution, area 27: **Hanaiki-Waimalu Ridge**, type locality 191*, elevation 1,200-1,250 feet, 1932; also 192, elevation 1,200-1,250 feet, Meinecke, 7 sinistral 1933 (figs. 4, 4a, p. 53). Also collected by Thurston, BBM 130604, 9 sinistral, Thwing, BBM 28751-28759, 26 sinistral.

At a lower elevation on the same ridge, possibly in the region of area 27A?, Thurston, 1910, BBM 130603, discovered a colony of dextral forms living on maile (*Alyxia*), and lehua (*Metrosidros*). Also collected by Cooke, BBM 72557-72558, 7 dextral, A. F. Judd, BBM 110492-110494 and 110496, Thwing, BBM 28986, 1 dextral.

The lightest color pattern (pl. 5, fig. 31), on 8 percent of the shells in the combined Meinecke-Thurston lots from area 27, has the postembryonic whorls white; impressed sutural and subsutural bands wood brown shading to bone brown on the last two whorls; last whorl banded and lined below and at the edge of the periphery with bister and snuff brown, about the umbilicus a band of bone brown; lip and columella callus natal brown.

The obese form of the shell (pl. 6, fig. 1) has a lined pattern which occurs on 13 percent of the shells; the first postembryonic whorl fawn color banded with white, penultimate army brown axially streaked with olive brown, and lined with white, last whorl above the periphery banded with a band of olive brown, and one of white, below the periphery a band about 5 mm. wide of cinnamon buff lined and banded with olive brown, base banded with pale pinkish buff, and a band of bister in the umbilical region. Length 18.8 mm., greater diameter 13.2 mm., spire height 9.5 mm.

A dextral shell of the usual form and color pattern from area 27A? (pl. 1, fig. 37) measures: Length 19.0 mm., greater diameter 12.4 mm., spire height 9.9 mm., number of whorls $6\frac{1}{8}$. The first postembryonic whorl and a half shades from fawn color to army

brown, axially streaked and finely lined with pale smoke gray, last whorl and a half bay profusely lined and streaked with tilleul buff, basal band warm sepia; outer margin of lip wood brown, inner margin vinaceous buff, columella callus white.

A narrow specimen (pl. 5, fig. 28) measures: Length 18.7 mm., greater diameter 11.3 mm., spire height 11.0 mm.; postembryonic whorls avellaneous, faintly axially streaked and spirally lined with army brown, last whorl below and at the periphery lined and banded with bister and snuff brown. An obese shell (pl. 5, fig. 29) shows a white color pattern occurring on 16 percent of the shells in the combined Cooke, Judd, and Thurston lots; postembryonic whorls white; impressed sutural band white, edged with sayal brown; last whorl below the periphery banded with light cinnamon drab, basal band fuscous. A white banded color pattern (pl. 5, fig. 30), has the postembryonic whorls white, banded with sayal brown, last whorl at and below the periphery banded with snuff brown.

In the Thurston lot (pl. 5 fig. 30a) a shell with the usual obese form has a pattern which resembles the form and type of banding of *A. a. pilsbryi*, but the color of the bands are entirely different on the two forms. The postembryonic whorls are white, last whorl banded below the periphery with chocolate; impressed sutural band chocolate. Length 18.4 mm., greater diameter 12.7 mm., spire height 9.2 mm. The presence of this chocolate-banded form in the Thurston lot is of interest, because it may be a representative of a still lower race, which is a chocolate-banded one and closely related to *A. a. pilsbryi*.

ACHATINELLA APEXFULVA PARVICOLOR, new subspecies

PLATE I, FIGURE 40; PLATE 6, FIGURES 15-15c

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 295, 298, pl. 56, figs. 3, 3a (only), 1914.

This form is smaller than *A. a. turgida* and has a light color pattern and never has the dark diamine brown or yellow color patterns of *A. a. turgida*. The subspecies is not found today, being a race collected by Gulick and identified by him as *turgida*. The embryonic whorls of the holotype (pl. 1, fig. 40) are white; postembryonic whorls pale pinkish buff, axially streaked with sayal brown, peripheral band on the last whorl pale pinkish buff; edge of the lip fawn color. Length 19.2 mm., greater diameter 12.7 mm., spire height 10.3 mm., number of whorls 6 $\frac{1}{4}$.

Distribution, area 36???: Waimalu?, Gulick. I have tentatively placed the probable locality somewhere in Waiau and Punanani

Gulch, because this region is often referred to as Waimalu by some collectors. The race may have come from somewhere near area 35 because the shell looks so like forms of *A. a. turgida* (fig. 4a, p. 53).

The lightest color pattern and extreme obese form (pl. 6, fig. 15) has the postembryonic whorls pale pinkish cinnamon, spotted on the first two postembryonic whorls and banded just below the impressed sutural band on the last whorl with cinnamon buff, below the periphery of the last whorl faintly lined with dots of cinnamon buff. Length 17.2 mm., greater diameter 13.0 mm., spire height 9.0 mm.

An elongate dextral (pl. 6, fig. 15a) measures: Length 18.8 mm., greater diameter 11.5 mm., spire height 10.7 mm.; embryonic whorls worn; postembryonic whorls pale pinkish cinnamon axially streaked with sayal brown, banded on the last half whorl below the periphery with a band of verona brown.

Plate 6, figure 15b, shows an obese sinistral specimen with a color pattern similar to plate 1, figure 40. An elongate sinistral (pl. 6, fig. 15c) with a color pattern similar to the holotype, measures: Length 19.1 mm., greater diameter 11.8 mm., spire height 11.0 mm.

GROUP OF *A. A. TURGIDA* NEWCOMB

ACHATINELLA APEXFULVA OVUM PFEIFFER

PLATE 1, FIGURE 26; PLATE 5, FIGURES 9-11

Achatinella ovum PFEIFFER, Proc. Zool. Soc. London, 1856, p. 334.

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 297, pl. 59, fig. 17 (only), 1914.

The holotype (pl. 5, fig. 9) in the British Museum, marked with a red dot of sealing wax, is entirely white except for the black lip. Length 19.4 mm., spire height 10.3 mm., number of whorls $6\frac{1}{4}$. The other two shells in the type lot are white dextral specimens. One is not adult, the other (pl. 5, fig. 10) is fully developed and marked specimen A; the lip is black. Length 17.8 mm., greater diameter 12.7 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 22: **North-Central Halawa Ridge**, locality 162C*, elevation 1,400-1,450 feet, Meinecke, 1930 (figs. 4, 4a, p. 53). Also collected by Wilder, BBM 50525.

The holotype probably came from area 22 because that area is the lowest containing sinistral shells. The dextrals in the type lot may have come from a lower locality somewhere near area 21. Only six live shells are known to come from area 22. The colors are equally divided between the typical white *ovum* pattern of plate 1,

figure 26, and the lined pattern of plate 5, figure 11. The usual pattern (pl. 1, fig. 26) and form of the shell from area 22 has the postembryonic whorls white; about 3 mm. behind the edge of the lip the last whorl is ornamented with a streak of sayal brown and banded with a band of brownish black; lip brownish black shading to cinnamon drab on the inner edge, near the columella callus the outer edge is also cinnamon drab. Length 20.0 mm., greater diameter 13.7 mm., spire height 10.0 mm., number of whorls $6\frac{1}{2}$. The lined pattern (pl. 5, fig. 11) has the embryonic whorls white shading to pale pinkish buff on the first half of the first postembryonic whorl, last half pinkish buff, last two whorls pale pinkish buff banded and lined with pinkish buff and cinnamon buff, the last $2\frac{1}{2}$ mm. behind the edge of the lip bone brown or a blackish brown; lip a blackish brown; tip of columella callus white, shading to vinaceous fawn, near the closed umbilicus. So few of the specimens were available for study that the typical form was not determined.

ACHATINELLA APEXFULVA OVUM var. 1

PLATE 1, FIGURE 25; PLATE 5, FIGURES 8, 8a

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 298, pl. 56, fig. 10 (only), 1914.

Area 21: **North-Central Halawa Ridge**, locality 160C*, elevation 1,000-1,100 feet, Meinecke, 1 dextral 1930; **Central Halawa** region of 162B*, elevation 1,050-1,250 feet, Meinecke, 1914; also collected by Thurston, BBM 130505 (figs. 4, 4a, p. 53).

The shells of area 21 differ from those of area 22 in being dextral, smaller, and having an impressed sutural band of sayal brown on the first postembryonic whorl, on the remaining whorls the sutural band is white, fringed with sayal brown at the upper edge, or entirely white.

The usual form of the shell (pl. 1, fig. 25) measures: Length 18.7 mm., greater diameter 12.5 mm., spire height 9.8 mm., number of whorls $6\frac{1}{2}$. The shell is a dead specimen but retains most of the shell nacre; postembryonic whorls white slightly tinted with cream color just behind the edge of the lip; lip army brown.

In a fresh specimen (pl. 5, fig. 8) embryonic whorls a light shade of cream color; first postembryonic whorl cream color shading to white on the penultimate and first half of the last whorl, last half whorl above the periphery ivory yellow, last whorl below the periphery cream color lined and banded with avellaneous. Length 17.3 mm., greater diameter 12.4 mm., spire height 9.2 mm.

A narrow shell (pl. 5, fig. 8a) measures: Length 18.2 mm., greater diameter 11.8 mm., spire height 10.2 mm.; the shell is white except for the first postembryonic whorl and a half which is lined with ochraceous fawn and has the impressed sutural band ochraceous tawny; lip army brown.

ACHATINELLA APEXFULVA OVUM var. 2

PLATE 1, FIGURES 27, 28, 31; PLATE 5, FIGURES 12-14

Area 23: **North-South Halawa Ridge**, locality 162D*, elevation 1,500-1,750 feet; 164D*, elevation 1,500-1,650 feet, 5 sinistral; 165D*, elevation 1,400-1,500 feet, 4 sinistral, all Meinecke-collected, 1930. Also collected probably in the region of areas 22 and 23 by J. S. Emerson, BBM 102211, by Dos Santos, BBM 74314, Thurston, BBM 130506, Wilder, BBM 50523 (figs. 4, 4a, p. 53).

Area 24: **Halawa-Kalauao Ridge**, locality 174*, elevation 1,550 feet, 1930; 176-1, elevation 1,650 feet, 2 sinistral 1936; 176-2, elevation 1,700-1,750 feet, 1 sinistral 1936; 176*, elevation 1,650-1,700 feet, 1 sinistral 1930 (figs. 4, 4a, p. 53) all Meinecke-collected. **Aiea**, J. S. Emerson, BBM 102446, 6 sinistral.

The shells of areas 23 and 24 are characterized by having certain yellow color patterns mixed with the usual *A. a. ovum* pattern of area 22.

The usual form of the shell in area 23 (pl. 5, fig. 12) measures: Length 19.4 mm., greater diameter 13.0 mm., spire height 9.5 mm.; and has a color pattern similar to that of *A. a. ovum* (pl. 1, fig. 26).

A distinctive yellow color pattern (pl. 1, fig. 27) has the embryonic whorls white; first postembryonic whorl white, impressed sutural band ochraceous tawny; first half of the penultimate whorl white, impressed sutural band light pinkish cinnamon, last half of penultimate and last whorl Naples yellow, banded at the edge of the periphery with white, impressed sutural band color of ground; lip seal brown or bone brown; columella callus fawn color. Length 19.5 mm., greater diameter 12.8 mm., spire height 10.5 mm.

In the Wilder lot (BBM 50523) of 30 shells, 50 percent are white and resemble *A. a. ovum* (pl. 1, fig. 26). The usual form of the shell (pl. 5, fig. 13) measures: Length 20.1 mm., greater diameter 13.7 mm., spire height 10.0 mm. Four shells in the lot have a yellow pattern (pl. 1, fig. 27), seven a yellow banded or lined pattern (pl. 5, fig. 11). One of the yellow-banded shells, an elongate form, has unusually dark bands (pl. 1, fig. 28). The postembryonic whorls are ochraceous tawny, finely or faintly lined with white, last whorl below the

periphery banded with a band of white, a line of ochraceous tawny, base pale pinkish buff, darkening to warm sepia behind the edge of the lip. Length 20.7 mm., greater diameter 13.1 mm., spire height 11.1 mm.

In area 24 the usual color pattern and form (pl. 1, fig. 31) is a white shell with pale pinkish buff embryonic whorls; lip and columella callus light seal brown. Length 19.2 mm., greater diameter 12.7 mm., spire height 10.0 mm. The shell is a little narrower than the usual form. The yellow-lined pattern of this area (pl. 5, fig. 14) has the postembryonic whorls white with a band of cream buff above the periphery, last whorl banded at the edge of the periphery with a band of white, below the periphery banded with chamois shading to white in the umbilical region, and lined with two lines of cinnamon.

ACHATINELLA APEXFULVA OVUM var. 3

PLATE 1, FIGURE 24; PLATE 5, FIGURES 6, 7

Area 20: **Moanalua-Halawa Ridge**, locality 163*, elevation 1,500-1,620 feet, Meinecke, 9 sinistral 1930. Also collected somewhere on the same ridge by O. H. Emerson, BBM 103964, 1915 on maile (*Alyxia*) and hoe (hoi?, *Dioscorea*); J. S. Emerson, BBM 102209, 1915 (figs. 4, 4a, p. 53).

The usual color pattern of the shells in area 20 is similar to that of *A. a. ovum* (area 22), but other patterns occur which do not resemble those found in area 22. The embryonic whorls are very slightly bi-colored but are closer to *A. a. ovum* than to *A. a. simulans*.

The usual form in the Meinecke lot from locality 163* (pl. 1, fig. 24) measures: Length 20.2 mm., greater diameter 13.2 mm., spire height 10.5 mm.; the embryonic whorls are not usual, being more pointed, first embryonic whorl light vinaceous fawn, remaining embryonic whorls white shading to pale pinkish buff; first postembryonic whorl white, lined with pinkish buff, remaining whorls white, 3 mm. behind the edge of the lip a streak of verona brown, banded with warm sepia; impressed sutural band pinkish buff shading to white on the last whorl. A peculiar pattern (pl. 5, fig. 6) has the embryonic whorls white, first embryonic whorl slightly darker than the rest; postembryonic whorls above the periphery ochraceous buff deepening to cinnamon on last half whorl, and lined on the last two whorls with white; impressed sutural band cinnamon, at and below the periphery the base is white, with a central line of cinnamon.

A third color pattern (pl. 5, fig. 7) shown on the usual form of the shell in the O. H. Emerson and J. S. Emerson lots has the postem-

bryonic whorls white, first postembryonic whorl banded with ochraceous tawny, penultimate whorl with a sutural band and a band just above the edge of the periphery of russet, last whorl lined at the edge of the periphery with buckthorn brown, subperipheral band russet, base banded with tawny; lip army brown. Length 19.5 mm., greater diameter 13.7 mm., spire height 10.0 mm.

ACHATINELLA APEXFULVA BRUNEOLA, new subspecies

PLATE I, FIGURE 32; PLATE 5, FIGURES 17-17b

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 298, pl. 56, fig. 8a (only), 1914.

The shell resembles *A. a. ovum* in form, but differs in having a brown color pattern. Embryonic whorls of the holotype (pl. 1, fig. 32) white; first half postembryonic whorl shades from white to ochraceous tawny, penultimate and last whorl sudan brown, at the periphery and below the periphery of the last whorl the ground is argus brown, lined and banded with apricot yellow; lip verona brown; columella callus tilluel buff. Length 19.0 mm., greater diameter 13.0 mm., spire height 9.7 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 28: **Kalauao-Hanaiki Ridge**, type locality 182, elevation 1,300-1,367 feet, Meinecke, 1926, 3 dextral 1929, 2 dextral 1933 (figs. 4, 4a, p. 53).

The holotype has the usual form of the shell, and a color pattern which occurs on 33 percent of the shells. An elongate shell (pl. 5, fig. 17) has the usual color pattern on 58 percent of the shells; postembryonic whorls ochraceous tawny spirally banded with russet, below the periphery of the last whorl prout's brown with a few lines of yellow ochre; lip and columella callus mars brown. Length 19.3 mm., greater diameter 12.2 mm., spire height 10.7 mm. A squat specimen (pl. 5, fig. 17a), with a similar color pattern to figure 17, has a very concave spire and inflated last whorl; the postembryonic whorls are profusely lined with russet. Length 19.0 mm., greater diameter 13.4 mm., spire height 8.9 mm. The lightest color pattern found on a single specimen (pl. 5, fig. 17b) has the first two postembryonic whorls pale ochraceous buff and lined with wood brown darkening to fawn color, last whorl above the periphery pale ochraceous buff lined with natal brown and buffy brown, at and below the periphery the ground is chamois above and within the aperture, the remainder of the whorl is cartridge buff; lip and columella callus army brown streaked with white.

ACHATINELLA APEXFULVA BRUNEOLA var. 1

PLATE 1, FIGURE 33; PLATE 5, FIGURE 18

Area 29: **Kalauao-Hanaiki Ridge**, locality 183, elevation 1,300-1,350 feet, Meinecke, 13 sinistral 1935; 183², Meinecke, 1913 (figs. 4, 4a, p. 53).

The usual form of the shell is larger than typical *A. a. bruncola*, the mean length 20+mm. instead of 19+mm. The color pattern differs from typical *bruncola* by having the base banded with yellow; the shells are usually sinistral. The form is an intermediate one between the higher race of *A. a. aureola* and *A. a. bruncola*.

The usual form and color pattern of the shell (pl. 1, fig. 33) has the embryonic whorls white or pale pinkish buff, last two postembryonic whorls amber brown, peripheral band and base light cadmium, subperipheral band chestnut, below which are lines of amber brown and a band about the umbilicus of a deep shade of mars brown, behind the edge of the lip last whorl tinted with a streak of chestnut. Length 20.4 mm., greater diameter 13.1 mm., spire height 10.7 mm., number of whorls 6½. The color of a dextral shell (pl. 5, fig. 18) shows the light color pattern of the shell; postembryonic whorls mars yellow or a light shade of sudan brown, base cadmium with a subperipheral band of chestnut.

ACHATINELLA APEXFULVA BRUNEOLA var. 2

PLATE 1, FIGURE 30; PLATE 5, FIGURES 15-16

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 298, pl. 56, figs. 7-7d (not from Moanalua but from Aiea, according to Dr. Cooke) and figure 6 (only), 1914 (figure 6 also matches color patterns of *A. a. ovum* var. 2).

Area 25: **Aiea-Kalauao Ridge**, locality 170C-6*, elevation 1,550-1,800 feet, Lemke, 1924 and 1932 (figs. 4, 4a, p. 53); also collected in **Aiea** by Cooke, BBM 72501-72512, BBM 72514, BBM 16346-16347, A. F. Judd, BBM 110211-110224, Wilder, BBM 50528, 15 sinistral.

The main difference between the shells of area 25 and typical *bruncola* is that the dominant color pattern is a yellow-lined form instead of the darker usual *bruncola* pattern of plate 5, figure 17. The yellow shells are rare in area 28, whereas in area 25, 21 percent have a definitely yellow pattern without strong brown bands (pl. 5, fig. 15).

The usual form and color pattern of 37 percent of the shells (pl. 1, fig. 30) has the embryonic whorls white; first quarter postembryonic whorl white, next quarter tawny lined with pale pinkish buff, penulti-

mate cream buff lined with tawny, last whorl antimony yellow lined above the periphery with tawny, below and at the periphery with chestnut; lip warm sepia, columella callus white. Length 18.7 mm., greater diameter 12.5 mm., spire height 9.6 mm., number of whorls $6\frac{1}{4}$.

Eight percent are dark brown above the periphery and yellow below (pl. 5, fig. 15a); the postembryonic whorls tawny faintly lined or tinted with warm buff, banded above and below the periphery with chestnut, below and at the periphery the ground is naples yellow. The typical form of a shell of the 19+mm. length class (pl. 5, fig. 15) measures: Length 19.7 mm., greater diameter 13.6 mm., spire height 10.0 mm.; postembryonic whorls shade from white to light buff on the last half of the penultimate, last whorl above the periphery white, tinted with light buff, finely spirally lined with faint lines of chamois, below the periphery ground is mustard yellow within the aperture lightening to naples yellow, and spirally lined with buckthorn brown, except behind the edge of the lip where the bands and lines are russet; impressed sutural band russet. The lightest yellow pattern (pl. 5, fig. 15b) has the postembryonic whorls white up to the last whorl which is mustard yellow with a line of ochraceous tawny at the edge of the periphery.

The dextral race of *bruneola* var. 2 is probably a remnant of two races. The lower, a brown race similar to typical *A. a. bruneola*, may possibly have been a pure one and not mixed with the yellow or upper form similar to *A. a. aureola*. Above the brown race yellow forms existed, and locality 170C-6 is the point where the two races overlapped.

The Wilder lot, BBM 50528, may indicate that a yellow race occurs between areas 24 and 25. The shells were probably collected over a wide area inclusive of area 24 because of the presence of white shells; and above area 25 because no dextrals are found in the lot. One specimen has a brown color pattern (pl. 5, fig. 16); postembryonic whorls white, banded on the first postembryonic whorl with tawny, last whorl banded with chestnut. Thirty-three percent have a yellow pattern similar to that of plate 5, figure 15. Sixty percent have whitish color patterns similar to those of plate 1, figure 31, and plate 5, figure 6. The yellow shells are probably a sinistral race of *A. a. aureola*, but because the locality is not definite, the range of color variation is not known and these shells have therefore been lumped with *A. a. bruneola* var. 2 until more data are obtainable. In like manner the white forms are probably *A. a. ovum* var. 2.

ACHATINELLA APEXFULVA AUREOLA, new subspecies

PLATE I, FIGURES 34, 35; PLATE 5, FIGURES 19-21a

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 298, pl. 56, fig. 8 (only), 1914.

The shell is obese and resembles *A. a. bruneola* in form, but differs in the color pattern, having a yellow ground usually lightly banded with brown. The embryonic whorls of the holotype (pl. 1, fig. 34) are white; first postembryonic whorl pale pinkish buff axially streaked with sayal brown, penultimate whorl pale pinkish buff axially streaked with ochraceous tawny; impressed sutural band ochraceous tawny, last whorl above the periphery pale pinkish buff, banded at edge of the periphery and above the periphery with a band 2.8 mm. wide, amber brown above the aperture, the band is lined with mustard yellow, and on the last half whorl breaks up into three bands of amber brown, just behind the edge of the lip a streak of warm sepia, last whorl below the periphery mustard yellow; lip army brown streaked with white; columella callus army brown shading to white at the tip of the callus. Length 20.4 mm., greater diameter 14.1 mm., spire height 9.8 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 30: Kalauao-Hanaiki Ridge, type locality 184, elevation 1,350-1,450 feet, 1926, also 1913, 7 sinistral 1929, 8 sinistral 1935; 185, elevation 1,450-1,500 feet, 1933; 187, elevation 1,600 feet, 1933; 187?, 1932; 188, elevation 1,650-1,700 feet, 1 sinistral 1933, all Meinecke-collected (figs. 4, 4a, p. 53).

The form of the shell in locality 184 may be more elongate (pl. 5, fig. 20) and have a darker spire than the holotype. Length 20.2 mm., greater diameter 13.0 mm., spire height 10.6 mm. Last half of first postembryonic whorl, penultimate, and last whorl above the periphery tawny buff, lined, banded, and streaked with a shade of color between ochraceous tawny and avellaneous; impressed sutural band same color; last whorl at the edge of the periphery banded with tawny, below the periphery mustard yellow and with a line of tawny, behind the edge of the lip a streak of black. A single specimen (pl. 5, fig. 19) has a white spire; last whorl below and just above the periphery Naples yellow, banded with white at the edge of the periphery, below the periphery banded with amber brown, just behind the edge of the lip a streak of black.

The lightest color pattern in locality 185 (pl. 5, fig. 20a) has white postembryonic whorls, banded and lined with tawny and ochraceous tawny, last half whorl banded at the edge of the periphery with Mars brown, behind the edge of the lip a streak of black or Mars brown.

The dextral shells of locality 187 are not so obese as those of locality 184. The usual form and pattern of a dextral (pl. 1, fig. 35) measures: Length 19.8 mm., greater diameter 12.4 mm., spire height 10.5 mm., embryonic whorls white; postembryonic whorls shade from cream color to naples yellow on the last whorl, last whorl below the periphery mustard yellow, banded at the edge of the periphery with a faint band of ochraceous tawny, below the periphery with tawny, behind the edge of the lip a streak of black.

The obese and banded form of the shell (pl. 5, fig. 21) measures: Length 18.9 mm., greater diameter 13.3 mm., spire height 8.8 mm. Postembryonic whorls mustard yellow, faintly lined on the last whorl above the periphery with cinnamon buff; impressed sutural band russet; last whorl at the periphery and below banded with ochraceous tawny, russet and mars brown about the base, behind the edge of the lip a streak 2 to 3 mm. wide of black. A narrow elongate form and a yellow color pattern (pl. 5, fig. 21a) has the postembryonic whorls naples yellow deepening to yellow ochre on the last whorl, lined above the periphery of the last whorl with naples yellow. Length 20.2 mm., greater diameter 12.0 mm., spire height 11.1 mm.

There is some doubt in my mind concerning the accuracy of some of the material collected by Meinecke in localities 184 and 187. After comparing the material with his more recently collected shells found after 1933, I believe that the early lots of shells collected prior to 1933, and plotted from memory, have been misplotted. I have taken the liberty of arranging the sequence of areas in a probably correct order, taking the 1933 and later collected material to be correct. In doing so I may have made an error, and I hope that some student of Hawaiian tree snails may check the order of color variations on this ridge. The change in form from narrow dextral shells in area 28 to sinistral obese ones in locality 184 and finally to narrow dextrals again in locality 187 is most interesting if true. On the variation of form, one would be led to suppose that the sequence is area 28, locality 187, area 29, locality 184, and finally locality 185, locality 188, and area 31.

In locality 185 the color pattern and form of the shells is similar to that of locality 184, the only difference being that a few specimens (3 out of 10) have a white ground in locality 185, while in area 184 no white color patterns occur. The single shell from 188 has an entirely yellow color pattern. I have considered this locality the borderline extremity of the typical *aureola* area with a few specimens showing the lighter color patterns of area 31.

ACHATINELLA APEXFULVA AUREOLA var. 1

PLATE 1, FIGURE 36; PLATE 5, FIGURES 22-22b

Area 31: **Kalauao-Waimalu Ridge**, locality 190A*, elevation 1,750-1,800 feet, 1932; 191A*, elevation 1,600 feet, 5 sinistral 1932, all Meinecke-collected (figs. 4, 4a, p. 53).

The color pattern of the shells in this sector are white shells banded or tinted with yellow or banded with brown. A usual pattern in locality 190A* (pl. 5, fig. 22) has the postembryonic whorls white, the last half of the first postembryonic whorl and the first half of the penultimate faintly lined and banded with tawny, the last half of the penultimate faintly banded and lined with cream buff, the first half of the last whorl mustard yellow with a peripheral band and supraperipheral line of buckthorn brown, last half whorl white tinted with mustard yellow, with the peripheral band buckthorn brown, behind the edge of the lip a streak of mars brown. A brown color pattern (pl. 5, fig. 22a) has the postembryonic whorls above the periphery antimony yellow axially streaked and lined with amber brown; impressed sutural band chestnut; last whorl and a half at the edge of the periphery and below the periphery white tinted with cream color, in the umbilical region a patch of amber brown. A white color form (pl. 5, fig. 22b) resembles *A. a. ovum*. The entire shell is white, tinted on the last whorl with mustard yellow, last fourth whorl faintly banded with mustard yellow, behind the edge of the lip mars brown.

In the higher locality of 191A*, the usual color pattern (pl. 1, fig. 36) is a white shell banded on the last whorl above the periphery and all below the periphery with mustard yellow. The shells in the upper region are all sinistral; in 190A* they are all dextral.

ACHATINELLA APEXFULVA WAIMALUENSIS, new subspecies

PLATE 1, FIGURE 45; PLATE 5, FIGURES 25, 25a

The shell looks like a form of *A. a. ovum* or *A. a. aureola* and their varieties, but is distinct from them in having the first postembryonic whorl banded with brown so that the whorl stands out, being darker than the whorls above and below it. The *A. a. ovum* and *A. a. aureola* forms have a color pattern which usually darkens consistently on the later whorls.

The embryonic whorls of the holotype (pl. 1, fig. 45) are cartridge buff; first postembryonic whorl banded on the lower portion of the whorl with ochraceous tawny, the band decreasing from three-fourths the width of the whorl to half its width, on the white penultimate and

last whorl the band narrows to a line and fades from ochraceous tawny to a light shade of ochraceous tawny; below the periphery of the last whorl the shell is banded with a light shade of ochraceous tawny, base cream color; lip russet; columella callus light vinaceous fawn. Length 20.7 mm., greater diameter 13.1 mm., spire height 11.4 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 32: **Waimalu-South Central Waimano Ridge**, type locality 204C, elevation 1,660 feet, Meinecke, 6 sinistrals 1933; also 202C, elevation 1,500-1,550 feet; 203C, elevation 1,600-1,660 feet; 206C, elevation 1,600 feet, Meinecke, 1 sinistral 1933 (figs. 4, 4a, p. 53).

The darkest color pattern (pl. 5, fig. 25) has the first half post-embryonic whorl banded on the lower half of the whorl with a light shade of clay color lined with white and fading to white on the last half of the whorl, the penultimate whorl is white, lined on the lower portion just above the edge of the periphery with honey yellow shading to chamois, the last whorl is chamois all below the periphery and just above the periphery, the remainder of the shell is white, below the periphery banded with tawny.

The lightest pattern (pl. 5, fig. 25a) has the last two whorls white, tinted and faintly spirally banded with naples yellow, behind the edge of the lip a streak or axial stripe of black.

ACHATINELLA APEXFULVA WAIMALUENSIS var. 1

PLATE I, FIGURE 44

Area 32A: **South Central Waimano-Central Waimano Ridge**, locality 202D, elevation 1,400 feet; 203D, elevation 1,450 feet, Meinecke, 1933 (figs. 4, 4a, p. 53). Only one live specimen has been collected in area 32A. The other shells are such dead specimens that the range of color patterns is not known.

The color pattern on the live shell (pl. 1, fig. 44) from locality 202D is a shell with a color pattern similar to *A. a. waimaluensis* (pl. 5, fig. 25), except that the spire is banded. The first embryonic whorl is broken off, the remaining embryonic whorls light buff; postembryonic whorls white, banded with ochraceous tawny, lower half of last whorl naples yellow with a line of ochraceous tawny at the edge of the periphery, on the last half whorl three bands of warm sepia; lip not formed; columella callus pale vinaceous fawn. The color pattern is intermediate between *A. a. simulacrum* and *A. a. waimaluensis*, but closest to *waimaluensis*.

ACHATINELLA APEXFULVA TURGIDA Newcomb

PLATE I, FIGURE 41; PLATE 6, FIGURES 2-10

Achatinella turgida NEWCOMB, Proc. Zool. Soc. London, 1853, p. 134, pl. 22, figs. 10-10a.—PILSBRY and COOKE, Man. Conch., vol. 22, p. 294, pl. 29, figs. 10-10a; pl. 56, figs. 1-2, 4, 11 (only), 1914.

Achatinella swiftii NEWCOMB, Proc. Zool. Soc. London, 1853, p. 133, pl. 22, figs. 9, 9a.—PILSBRY and COOKE, Man. Conch., vol. 22, p. 306, pl. 29, figs. 9, 9a (only), 1914.

Newcomb's description of *A. a. turgida* may refer to either of his original figures. I shall choose his figure 10 (pl. 6, fig. 2) to be the lectotype, because it has the most usual pattern. The original specimen (pl. 6, fig. 3) of Newcomb's figure 10 has white embryonic whorls; penultimate and last postembryonic whorls pallid mouse gray, axially spotted and spirally banded with hessian brown, on the last whorl near the middle of the whorl there are three axial bands of cinnamon, behind the edge of the lip an axial band of hessian brown, in the umbilical region below the last hessian brown band the ground is cream buff, mixed with pallid mouse gray; impressed sutural band hessian brown; lip and columella callus light vinaceous fawn. Length 19.7 mm., greater diameter 13.4 mm., spire height 10.9 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 35: **Waiiau-South Waimano Ridge**, locality 200B*, elevation 850-1,000 feet, 7 dextral, 1 sinistral 1929; 202B, elevation 1,000-1,150 feet, 1913, 1 dextral, 8 sinistral 1914, 1920, 7 dextral, 2 sinistral 1929, 12 dextral, 1 sinistral 1932, 1934; 202BB*, elevation 1,050-1,150 feet, 5 dextral, 1 sinistral 1929, all collected by Meinecke. **Waimano**, Wilder, BBM 50598; **Waimalu**, J. S. Emerson, BBM 102218. Pilsbry and Cooke report *A. a. turgida* to have been taken in Waiawa by I. Spalding. This is an error, for no *A. a. turgida* are found except in the region of Waimalu to Waimano (figs. 4, 4a, p. 53). Holotype in BM marked with an x.

The usual form and color pattern (pl. 1, fig. 41) of *A. a. turgida* in area 35 is very much like the lectotype in color. The shell measures: Length 19.0 mm., greater diameter 13.2 mm., spire height 10.1 mm., number of whorls $6\frac{1}{2}$. The embryonic whorls are white; postembryonic whorls diamine brown, spotted and banded with broken bands of pale smoke gray tinted with chamois; impressed sutural band diamine brown; lip and columella callus pale vinaceous fawn.

The darkest or reddish-brown color pattern and narrow form of the shell (pl. 6, fig. 4) has the postembryonic whorls diamine brown and looks like a sinistral specimen of *A. a. apexfulva* which has white embryonic whorls instead of yellow ones. Length 19.5 mm., greater diameter 12.6 mm., spire height 10.0 mm.

The usual yellow pattern and obese form of the shell (pl. 6, fig. 4a) has the first half postembryonic whorl ochraceous tawny banded on the lower half of the whorl with pale ecru drab, remaining whorls chamois spotted with snuff brown, hessian brown, and saccardo's umber, supraperipheral band on the last whorl warm sepia, last whorl below the periphery ornamented with zigzag streaks of snuff brown; impressed sutural band warm sepia. Length 19.4 mm., greater diameter 14.5 mm., spire height 9.7 mm.

The lightest or yellowish white color pattern (pl. 6, fig. 4b) has the postembryonic whorls white, on the first quarter whorl a patch of mars brown, remaining whorls streaked with ochraceous tawny; impressed sutural band on the first postembryonic whorl and a half diamine brown, last whorl and a half the sutural band is the color of the whorl below; lip light vinaceous fawn.

The typical form of a dextral shell and a variant of the yellow color pattern is figured on plate 6, figure 4c; first two postembryonic whorls pale gull gray, axially streaked with zigzag lines of neutral gray and deep neutral gray, and ochraceous tawny, last whorl cartridge buff tinted with cream color streaked with white and with axial splotches of ochraceous tawny, prout's brown, and mars brown. Length 19.5 mm., greater diameter 13.7 mm., spire height 9.4 mm.

A characteristic gray color pattern (pl. 6, fig. 4d) is also found in all *turgida* localities; the postembryonic whorls are pale gull gray spirally banded lined and spotted with diamine brown. The yellow color pattern (pl. 6, fig. 4e) may lack or have very little axial spotting; the first two postembryonic whorls are cartridge buff tinted with deep olive buff, last whorl chamois spirally lined and banded with chestnut and faintly axially streaked on the last half whorl with chestnut.

The size of the dextral shells varies from narrow specimens (pl. 6, fig. 5) to obese forms (pl. 6, fig. 6). The shell of figure 5 is a peculiar rare color pattern of the reddish-brown form, having a subperipheral chamois band faintly streaked with tawny on the last whorl, the remaining postembryonic whorls diamine brown; outer margin of lip army brown shading to white on the inner margin; columella callus white. Length 19.1 mm., greater diameter 12.5 mm., spire height 10.6 mm. The obese form of figure 6 measures: Length 19.2 mm., greater diameter 14.1 mm., spire height 9.6 mm.; the postembryonic whorls diamine brown spirally lined with apricot yellow on the penultimate, and banded and lined on the last whorl with mars yellow, light buff, or antimony yellow, which bands are axially streaked and lined with diamine brown or mouse gray.

The specimens used by Newcomb for his original figures of *A. swiftii* were not located in the British Museum. One lot labeled the type of *A. swiftii* contained shells which do not match the original figures, and are forms of *A. a. perplexa*.

Newcomb's figure 9 (pl. 6, fig. 7) closely matches yellow forms splotched with brown of *A. a. turgida* (pl. 6, fig. 4c). In the Newcomb collection at Cornell University there is a specimen of *A. a. turgida* (pl. 6, fig. 9) which closely resembles Newcomb's figure 9. Plate 6, figure 10, shows a specimen which looks very much like Newcomb's figure 9a (pl. 6, fig. 8), the postembryonic whorls are diamine brown, penultimate whorl is lined with white, last whorl banded below the periphery with yellow ochre, with a line of diamine brown near the center of the band; lip light vinaceous fawn.

Since *A. swiftii* so closely resembles patterns of *A. a. turgida* I consider it to be a synonym of *turgida*. *A. swiftii* has page priority over *A. a. turgida* but I am reluctant to make *turgida* a synonym of *swiftii* since the type of *swiftii* has not been located and the type of *turgida* has. Moreover, since the original figures do not match the original description, there is some doubt about the exact identification of *A. swiftii*. Therefore it is best to put *swiftii* in the synonymy of *A. a. turgida*.

ACHATINELLA APEXFULVA MEADOWSI, new subspecies

PLATE I, FIGURE 42; PLATE 6, FIGURES 11-12

Achatinella turgida ovum PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 298, pl. 56, fig. 9 (only); pl. 56, fig. 12 (an intermediate form between *A. a. meadowsi* and *A. a. turgida* but closest to *meadowsi*), 1914.

The shell of the holotype (pl. 1, fig. 42) is a yellow-brown form of *A. a. turgida* differing mainly in color pattern; the embryonic whorls pale pinkish buff; postembryonic whorls yellow ochre heavily banded on the first two whorls and above the periphery of the last whorl with amber brown, below the periphery the amber brown bands are faint so that the color is mostly yellow ochre, in the umbilical region a band of black; impressed sutural band warm sepia or black; lip army brown; columella callus light vinaceous fawn; behind the edge of the lip a streak of black. Length 19.6 mm., greater diameter 13.7 mm., spire height 9.6 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 34: **South Waimano-South Central Waimano Ridge**, type locality 212b, elevation 1,300 feet; 213a-213b, elevation 1,350-1,400 feet, 17 sinistral; 213a, elevation 1,350 feet, all collected by Meinecke, 1933. Meadows and Welch (BBM 107555-

107556) collected this form on the **Waiau-South Waimano Ridge** somewhere above area 35. The exact locality was not plotted, so is not being used in this paper (figs. 4, 4a, p. 53).

A. a. meadowsi is found in the Meinecke lots of *A. a. turgida* from area 35, but only a few specimens in the different lots, and some lots entirely lack this color form. Area 35 of *A. a. turgida* is probably a borderline area between *A. a. meadowsi* and a distinct pure race of *A. a. turgida*. The subspecies is named after E. J. Meadows, of Honolulu.

The elongate form (pl. 6, fig. 11) measures: Length 20.0 mm., greater diameter 12.5 mm., spire height 11.0 mm.; postembryonic whorls yellow ochre lightly streaked, banded, and lined with ochraceous tawny, last whorl banded at and below the periphery with warm sepia, or black; impressed sutural band warm sepia or black.

The darkest color pattern (pl. 6, fig. 11a) has the postembryonic whorls carob brown banded on the last whorl and a half with a band of yellow ochre which is lined and streaked with ochraceous tawny.

An obese specimen (pl. 6, fig. 12) with the postembryonic whorls yellow ochre and very faintly lined and banded with ochraceous tawny, measures: Length 19.0 mm., greater diameter 14.0 mm., spire height 9.3 mm.

ACHATINELLA APEXFULVA MEADOWSI var. 1

PLATE 6, FIGURES 13-14a

In locality 213a (fig. 4, p. 53) two specimens are found which did not have the usual glossy surface of typical *A. a. meadowsi*, but have a very dull appearance. The postembryonic whorls (pl. 6, fig. 13) are pale pinkish buff spirally banded and lined with ochraceous tawny; impressed sutural band warm sepia or black.

Wilder (BBM 50537) obtained from somewhere in the Waimano region a series of the shells all of which are dull forms. The color pattern ranges from dark patterns such as plate 6, figure 14, to light ones such as plate 6, figure 14a. The dark color pattern has the postembryonic whorls chestnut streaked with antimony yellow, sub-peripheral band light buff with a central band of ochraceous tawny; impressed sutural band warm sepia. The light pattern (pl. 6, fig. 14a) is colored on the first postembryonic whorl with pinkish buff; impressed sutural band pinkish buff; banded in the umbilical region with snuff brown.

This dull form may be a variety of *A. a. meadowsi* which occurs on the Waimalu-South Waimano Ridge or somewhere between areas

34 and 35. The dull race as can be noted above has a wider range of color pattern than typical *A. a. meadowsi*.

ACHATINELLA APEXFULVA MEADOWSI var. 2

PLATE I, FIGURE 43; PLATE 5, FIGURES 23, 24

Area 33: Waimalu-South Central Waimano Ridge, locality 200Ca, elevation 1,200-1,350 feet, 1932; 200C, elevation 1,400 feet, 2 sinistrals 1933; 201Ca, elevation 1,250-1,400 feet, 10 sinistrals 1933; 201C, elevation 1,450 feet, 1933, all collected by Meinecke (figs. 4, 4a, p. 53). This form also collected by J. S. Emerson (BBM 102229).

From the dark brown *meadowsi* forms of area 34 the shells become much lighter in shade the higher the locality. Area 33 is really an intermediate one between the light color pattern of *A. a. waimaluensis* and *A. a. meadowsi*, but is closest to *meadowsi* in color pattern.

The usual color pattern (pl. 1, fig. 43) has the embryonic whorls light buff lightening to pale pinkish buff lined with white; first post-embryonic whorl pale pinkish buff lined with pinkish buff, penultimate whorl cream color, subsutural band light ochraceous buff, last whorl mustard yellow tinted with buckthorn brown; the impressed sutural band on the first postembryonic whorl shades from mikado brown to warm sepia, on the penultimate whorl the upper portion of the sutural band is banded with warm sepia, the lower half is that of the ground color, the width of the warm sepia band narrows continually so that on the last whorl only a fringe of warm sepia exists on the upper portion of the band; lip vinaceous brown; columella callus light vinaceous fawn.

The lightest color pattern (pl. 5, fig. 24) is pale pinkish cinnamon, tinted on the last whorl with faint lines of warm buff; impressed sutural band russet lightening to avellaneous on the last whorl. A pattern (pl. 5, fig. 23) that looks like a light form of *A. a. meadowsi* also occurs; postembryonic whorls maize yellow spirally lined or banded with a light shade of clay color or a yellowish shade of ochraceous tawny.

ACHATINELLA APEXFULVA PERPLEXA Pilsbry and Cooke

PLATE I, FIGURE 47; PLATE 6, FIGURES 16-19d

Achatinella turgida perplexa PILSBRY and COOKE, Man. Conch., vol. 22, p. 296, pl. 56, figs. 5-5d (only), 1914.

To quote from Pilsbry and Cooke:

The shell has a white ground indistinctly streaked with pale neutral gray, and encircled with numerous lines and bands of darker gray or olive brown. First

embryonic whorl cartridge-buff with the tip either white or a little darkened, bluish or fleshy, the rest of the embryonic whorls white. First neanic whorl often marked with brown. The lip is vinaceous pink or light brownish vinaceous, fading on the rather strong lip-rib. About 6 percent are sinistral.

Length 20.7 mm., diam. 13.6 mm., $6\frac{1}{2}$ whorls.

Length 18.0 mm., diam. 12 mm.

Lateral spurs, and northern ridge of Waimano Valley, C. M. Cooke. Cotypes, 1192 Cooke coll. and 108802 A.N.S.P.

The grayish color and pale lip are the chief characters of this race, of which there are about 130 specimens in Dr. Cooke's collection. It varies a good deal. The bluish-gray streaks are often absent, or visible only on the bands, and the latter vary from light to dark. The sutural margin is usually touched faintly or distinctly with tawny. Figures 5, 5a are typical patterns.

Distribution, area 40: **Waimano-Manana Ridge**, locality 221 $\frac{1}{2}$ *, elevation 1,050-1,100 feet, 1926; 222*, elevation 1,100-1,150 feet, 1929, both collected by Meinecke (figs. 4, 4a, p. 53). Cooke's type locality in **Waimano** probably extends over areas 40 and 44, because the type lot (BBM 72723-72753) contains a mixture of the typical *perplexa* patterns of area 40 and the *nigripicta* var. 1 patterns which in the Meinecke collection are limited to area 44. Other collectors of this form are Wilder, BBM 50550-50551, and J. S. Emerson, BBM 102243. The Emerson lot is dominantly from the upper region of area 44, while the Wilder lots come mostly from the lower area 40. Both lots have many intermediate forms the patterns of which would identify them with either area.

Pilsbry's plate 56, figure 5, is considered the lectotype and is reproduced in this paper on plate 6, figure 16. The figure is slightly larger in proportion to the other figures. All the typical *perplexa* forms of the original Cooke lot are studied. The usual form (pl. 1, fig. 47) and gray pattern on about 55 percent of the shells has the embryonic whorls white; first half postembryonic whorl pale pinkish buff axially streaked with cinnamon, remaining postembryonic whorls white finely axially streaked and lined with light drab or a shade between light drab and tawny olive, peripheral band on last whorl white; impressed sutural band a faint shade of tawny olive; lip and columella callus seashell pink. Length 18.4 mm., greater diameter 12.8 mm., spire height 10.0 mm.

A variant of the typical color pattern, which may be considered a grayish pattern (pl. 6, fig. 17), has the first half postembryonic whorl sayal brown banded with a line of pale pinkish buff, last half verona brown; penultimate whorl drab streaked and tinted with benzo brown on the first half of the whorl, lower fourth of the whorl banded with pale gull gray, last whorl pale gull gray axially streaked with white,

spirally banded above the periphery with a band of pale pinkish buff axially streaked with drab, peripheral line fuscous, subperipheral band warm sepia streaked with hair brown and smoke gray, basally lined with sepia; spire concave in outline.

The grayish color pattern (pl. 6, fig. 18) may be more lined than figure 17; first postembryonic whorl mikado brown, faintly lined with pale pinkish buff, penultimate whorl ground pale pinkish buff covered with close-set axial streaks of drab, cinnamon drab and benzo brown, spirally lined with fuscous, last whorl pale pinkish buff, banded above the periphery with a light drab band which is lined with olive brown, banded at the periphery with olive brown, below the periphery with hair brown, lined with fuscous, lip light vinaceous fawn. This pattern collected by Meinecke in area 40 is also found in the Cooke lots.

Brownish color patterns are depicted on plate 6, figures 17*a*, 17*b*. Figure 17*a* is an extreme elongate specimen, with the spire straight in outline. Length 19.2 mm., greater diameter 11.8 mm., spire height 11.1 mm. Postembryonic whorls mikado brown, spirally lined and faintly streaked with zigzag streaks of tilleul buff, peripheral band tilleul buff lined with vinaceous buff. Figure 17*b* is a darker color pattern and the obese form of the shell. Length 19.8 mm., greater diameter 13.5 mm., spire height 11.0 mm. First postembryonic whorl cream color, with impressed sutural band ochraceous tawny, last two whorls army brown streaked with pale smoke gray.

Meinecke found a white sinistral specimen in locality 221 $\frac{1}{2}$ * (pl. 6, fig. 18*a*) the postembryonic whorls white, first two postembryonic whorls lined with pinkish buff, last whorl lined with cinnamon buff.

While the paratype Cooke lots are all dextral, 46 percent of the shells in the Wilder collection are sinistral. These sinistrals have a different color pattern range from those collected by Cooke. Yellowish or pink color patterns occur. The usual form and color pattern of 50 percent of the sinistrals (pl. 6, fig. 19) has the embryonic whorls pale pinkish buff; first half postembryonic whorl pale pinkish buff, axially streaked with sayal brown, next half whorl streaked with army brown, penultimate and last whorl light drab axially streaked with hair brown, and banded below the suture with white, last whorl below the periphery white with two lines of benzo brown. Length 18.1 mm., greater diameter 12.3 mm., spire height 9.4 mm.

A variant (pl. 6, fig. 19*a*) of the typical gray color pattern has the first half of the first postembryonic whorl ochraceous tawny, last half russet, penultimate tawny olive lined with smoke gray, last whorl smoke gray spirally lined with tawny olive. It is an obese form. Length 18.2 mm., greater diameter 13.3 mm., spire height 9.4 mm.

Twenty-two percent have a yellow ground (pl. 6, fig. 19*b*) the last two whorls cream color with bands of buffy brown which are axially streaked with natal brown. Eleven percent are pinkish patterns. The darkest of these (pl. 6, fig. 19*c*) has the postembryonic whorls colored pinkish cinnamon. The lightest pink pattern (pl. 6, fig. 19*d*) is sea-shell pink axially streaked with onion-skin pink, and spirally banded and lined on the last whorl with pale vinaceous fawn.

ACHATINELLA APEXFULVA COOKEI Baldwin

PLATE I, FIGURE 49; PLATE 7, FIGURES 7-10, 12-12*d*

Achatinella cookei BALDWIN, Proc. Acad. Nat. Sci. Philadelphia, 1895, p. 220, pl. 10, fig. 15.

Achatinella turgida cookei BALDWIN, Pilsbry and Cooke, Man. Conch., vol. 22, p. 300, pl. 57, figs. 15-17, 1914.

Distribution, area 45: **Waimano-Manana Ridge**, locality 225*, elevation 1,300-1,400 feet, 35 sinistral 1929; 225-1, elevation 1,500 feet, 2 dextral 1933; 226*, elevation 1,300-1,426 feet, 15 dextral 1929, all collected by Meinecke (figs. 4, 4*a*, p. 53). Type lot BBM 167352 of 8 dextral, collected by C. H. Cooke and labeled **Ewa**. The D. D. Baldwin lot, BBM 54669, of 4 dextral, was obtained from C. H. Cooke. Type locality on the **Waimano-Manana Ridge** was later collected by C. M. Cooke, Jr., BBM 72697-72698, 4 dextral, 4 sinistral, and R. A. Cooke, BBM 58340, 7 dextral and 2 sinistral. Probably the later collections include a slightly different region than the type locality, because the type lots contain no sinistrals. Also collected by Wilder, in **Waimano**, BBM 50594-50595, 142 sinistral, and 13 dextral.

The exact location of the type locality has not been plotted, but the color patterns in the type lot in the Bishop Museum closely match those of the shells from area 45. The shell Baldwin used for his original figure cannot be found in either the Bishop Museum or the Academy of Natural Sciences of Philadelphia.

A shell in the Academy of Natural Sciences, figured on plate 7, figure 8, more closely approximates the form of Baldwin's figure reproduced on plate 7, figure 7, but differs in size, thickness of the lip, and in having a band of pinkish buff in the umbilical region. The embryonic whorls of figure 8 are white shading to cartridge buff on the last half embryonic whorl; postembryonic whorls pinkish buff, last whorl spirally lined with lines darker than the ground, on the last half whorl a band of white at the periphery, below the periphery

last whorl hessian brown; lip and columella callus light vinaceous fawn. Length 19.4 mm., greater diameter 14.2 mm., number of whorls 6. While the shell of figure 8 does not match the original figure and measurements in all details, it comes from what is supposed to be the type lot and best matches the form of Baldwin's original figure. This shell is therefore considered the lectotype.

The usual form of the shell selected from the original type lot collected by C. H. Cooke is shown on plate 7, figure 9; the embryonic whorls white; postembryonic whorls pale pinkish buff tinted with light buff, lower half of last whorl a dark shade of diamine brown or dark livid brown. Length 19.2 mm., greater diameter 13.4 mm., spire height 9.8 mm. A narrow specimen (pl. 7, fig. 10) obtained in the type lot has the postembryonic whorls white, with the base warm blackish brown. Length 19.5 mm., greater diameter 12.8 mm., spire height 10.4 mm.

Plate 1, figure 49, shows a dextral specimen from locality 225-1. The postembryonic whorls are white, last whorl lower half warm blackish brown. Length 19.5 mm., greater diameter 12.8 mm., spire height 10.6 mm., number of whorls $6\frac{1}{2}$.

The range of color patterns in the Wilder collection is shown on plate 7, figures 12-12d. All with the exception of the shell of figure 12d have the lower half of the last whorl a deep shade of diamine brown or warm blackish brown. The usual form and color pattern (pl. 7, fig. 12) has the postembryonic whorls white, tinted with ochraceous tawny; impressed sutural band ochraceous tawny. Length 18.3 mm., greater diameter 12.3 mm., spire height 9.7 mm. An elongate shell (pl. 7, fig. 12a) with an entirely white spire measures: Length 19.6 mm., greater diameter 12.3 mm., spire height 10.9 mm.

Thirty-six percent have a definitely yellow pattern. The usual form and color pattern of one of the yellow shells (pl. 7, fig. 12b) has the embryonic whorls cartridge buff; postembryonic whorls ochraceous tawny with an impressed sutural band of tawny. Length 19.0 mm., greater diameter 12.4 mm., spire height 9.9 mm. An obese shell and a lined form of the yellow pattern (pl. 7, fig. 12c) measures: Length 18.2 mm., greater diameter 13.1 mm., spire height 9.5 mm.; last two postembryonic whorls ochraceous tawny streaked with tawny and finely spirally lined with white. Five shells of the yellow pattern lack the typical dark *cookei* base. One of these (pl. 7, fig. 12d) has the postembryonic whorls light buff, faintly axially streaked or tinted ochraceous tawny; impressed sutural band ochraceous tawny.

ACHATINELLA APEXFULVA COOKEI var. 1

PLATE I, FIGURE 46

Area 39: **North Central Waimano-North Waimano Ridge**, locality 211B, elevation 1,350-1,425 feet; 212B, elevation 1,400 feet, 1 dextral, 3 sinistral; 213B, elevation 1,350-1,450 feet, 2 dextral; 214B, elevation 1,500-1,560 feet, 9 dextral, all Meinecke-collected, 1933 (figs. 4, 4a, p. 53).

The shells of area 39 have a series of color patterns similar to those of the shells of area 45. The only reason for separating the two areas is that a few shells occur in area 39 which do not have the usual solid dark base of typical *A. a. cookei* and differ from the patterns found in area 45. The shell may be white (pl. 1, fig. 46) with a single band of black or warm blackish brown below the periphery of the last whorl. One white specimen with a vinaceous fawn lip and a patch of black behind the edge of the lip, below the periphery, was found in locality 214 B.

ACHATINELLA APEXFULVA COOKEI var. 2

PLATE I, FIGURE 56; PLATE 7, FIGURES 11-11b

Area 49: **Manana-Waiawa Ridge**, locality 237f, elevation, 1,700 feet; 237fa, elevation 1,500-1,600 feet, Meinecke 1933 (figs. 4, 4a, p. 53).

Sandwiched in between *A. a. nigripicta* (area 50), and *nigripicta* var. 2 (area 48) is a small region containing shells with *A. a. cookei* patterns. The usual form and color pattern of the shell (pl. 1, fig. 56) is more obese than the usual form in area 45, and the base is banded instead of being a solid dark color. The embryonic whorls are pale pinkish buff; postembryonic whorls white, first half of last whorl lined at the edge of the periphery with olive brown, subperipheral band white, 2 mm. wide, tinted with pale mouse gray, on the last half whorl, peripheral band warm blackish brown, subperipheral band white, 1 mm. wide, base of last whorl warm blackish brown, with a band of cream buff and a line of amber brown. Length 19.1 mm., greater diameter 13.9 mm., spire height 9.0 mm., number of whorls $6\frac{1}{4}$.

The usual *cookei* base occurs on some specimens but the spire is usually lined (pl. 7, fig. 11a); postembryonic whorls pale pinkish buff spirally lined with ochraceous tawny. This shell is also the obese form. Length 19.8 mm., greater diameter 13.9 mm., spire height 10.1 mm. A rare pattern (pl. 7, fig. 11b), and an elongate shell found

on one specimen in locality 237f has the postembryonic whorls mars yellow, lined and faintly axially streaked with light buff, last whorl banded just below the edge of the periphery with pale pinkish buff, the ground below this band light buff spirally banded with mars yellow with a line of warm blackish brown; impressed sutural band russet. Length 19.0 mm., greater diameter 12.7 mm., spire height 10.7 mm. The darkest color pattern (pl. 7, fig. 11) found on only one specimen has the postembryonic whorls banded with argus brown, lined and axially streaked with light buff, last whorl just above the periphery and all below warm blackish brown. The color of the lip and columella callus is usually light vinaceous fawn.

ACHATINELLA APEXFULVA NIGRIPICTA, new subspecies

PLATE I, FIGURE 55; PLATE 7, FIGURES 3-4

Achatinella turgida simulacrum PILSBRY and COOKE, Man. Conch., vol. 22, p. 300, pl. 56, figs. 13-13b (only), 1914.

The shell of the holotype (pl. 1, fig. 55) has the embryonic whorls white; postembryonic whorls pale pinkish buff banded with a very deep shade of diamine brown or black; impressed sutural band same black color; lip and columella callus vinaceous fawn. Length 18.2 mm., greater diameter 12.2 mm., spire height 9.3 mm., number of whorls 6.

Distribution, area 50: **Manana-Waiawa Ridge**, type locality 237b, elevation 1,450-1,500 feet, 1933; also in locality 237c, elevation 1,350-1,400 feet; 237d, elevation 1,500 feet; 237e, elevation 1,600-1,650 feet, 3 sinistral, all Meinecke-collected, 1933 (figs. 4, 4a, p. 53). Another collector of this form is Vasconcellos in 1915, for Thurston, BBM 130587-130588.

A variation (pl. 7, fig. 3) of the typical color pattern, and an elongate shell, has a lighter colored spire; postembryonic whorls pale pinkish buff spirally lined, and banded with ochraceous buff, and lined with black, last whorl at and below the periphery black with a band of pale pinkish buff just below the periphery. Length 18.8 mm., greater diameter 12.3 mm., spire height 10.5 mm. A lined pattern (pl. 7, fig. 3a) has the embryonic whorls black or a deep shade of diamine brown, lined with light buff. The color pattern (pl. 7, fig. 3b) may be solid black or a deep shade of diamine brown, which looks like a form of *A. a. apexfulva*; the last half of the first postembryonic whorl is lined with white. A rare pattern (pl. 7, fig. 3c) on one or two shells has the postembryonic whorls white spirally lined with tawny and black, banded below the periphery with black; impressed sutural band tawny. This shell also shows the usual form

of a dextral. Length 18.2 mm., greater diameter 12.5 mm., spire height 9.3 mm. One white specimen (pl. 7, fig. 3*d*) has the impressed sutural band edged with vinaceous cinnamon; last whorl below the periphery lined with chocolate. Another light color pattern (pl. 7, fig. 4) has the postembryonic whorls light buff spirally lined with black.

ACHATINELLA APEXFULVA NIGRIPICTA var. 1

PLATE I, FIGURE 48; PLATE 7, FIGURES 1-2*g*

Achatinella turgida perplexa PILSBRY and COOKE, Man. Conch., vol. 22, p. 296, pl. 56, figs. 5*e*, 5*f* (only), 1914.

Area 44: **Waimano-Manana Ridge**, locality 223, elevation 1,250-1,300 feet, a few dextral juvenile shells, Meinecke, 1933 (figs. 4, 4*a*, p. 53). A few specimens are found in locality 225 mixed with typical *A. a. cookei* forms so that probably area 44 extends as far as this locality. Other collectors of this form are Wilder, BBM 10449-10450, Cooke, BBM 72700-72722, and J. S. Emerson, BBM 10717-10718. Their lots are usually mixed with forms from the lower region of area 40 and have been separated out from the lots of *A. a. perplexa*. The shells of area 44 are so close to *A. a. nigripicta* in form and color pattern that they can easily be confused with them. This form of *A. a. nigripicta* var. 1 usually has a more yellow ground color and no white color patterns. The placing of the bands on the shells also differs. *A. a. nigripicta* occurs opposite area 45 of *A. a. cookei* and not area 44 as one would suppose. All this region needs to be re-collected very carefully to note whether all areas have been accurately plotted.

The localized Meinecke material from area 223 is very scanty so that form and color-pattern range is not determinable. The shell may be dextral or sinistral. The embryonic whorls (pl. 1, fig. 48) are white; last two postembryonic whorls and a half pale pinkish buff spirally banded with a dark shade of diamine brown and faintly axially streaked on the last whorl above the periphery with grayish olive; lip not formed; columella callus light vinaceous fawn. A lighter color pattern (pl. 7, fig. 1) is pale pinkish buff on the postembryonic whorls, spirally lined with sayal brown, and with warm sepia on the penultimate, last whorl lined with warm buff above the periphery, warm sepia at the periphery, below the periphery, subperipheral band pale pinkish buff, a line of warm sepia and a band of cream buff about the base. A dark color pattern and a sinistral (pl. 7, fig. 1*a*), has the embryonic whorls white; first postembryonic whorl

white, banded and lined with ochraceous tawny, penultimate and last whorl above the periphery, upper half pale pinkish buff axially streaked and spirally lined with ochraceous tawny, lower half a deep shade of diamine brown or black, and banded about the base with ochraceous tawny.

In the J. S. Emerson collection there is a large series of these shells, with some *A. a. perplexa* specimens mixed from area 40. They are made up of yellow and reddish-brown patterns. The usual form and color pattern on 30 percent of the dextrals (pl. 7, fig. 2), has the embryonic whorls white; postembryonic whorls warm buff, spirally lined on the penultimate with verona brown, last whorl banded and lined with verona brown and snuff brown, peripheral band pale pinkish buff; lip and columella callus shell pink. Length 18.5 mm., greater diameter 12.7 mm., spire height 10.0 mm. The color pattern may be lighter (pl. 7, fig. 2a), postembryonic whorls warm buff, lined with ochraceous tawny; upper edge of impressed sutural band russet, lower half warm buff; base lined with warm sepia. This yellow form may be lined and banded on the last two whorls with diamine brown over a warm buff ground (pl. 7, fig. 2b). A variant of this pattern has a white peripheral band on the last whorl between the two diamine brown bands. Figure 2b shows an extreme obese dextral. Length 18.6 mm., greater diameter 14.0 mm., spire height 9.0 mm.

The reddish-brown pattern (pl. 7, fig. 2c) may be solid liver brown on the last two and a half whorls, first half postembryonic whorl ochraceous tawny and looks like a form of typical *A. a. apexfulva*. The form and usual color pattern of a sinistral shell (pl. 7, fig. 2d), has the last two whorls and a half liver brown, with a band of pale pinkish buff at the periphery on the first half of the last whorl, and a band or line of warm buff above the periphery on the last half of the last whorl. Length 19.8 mm., greater diameter 13.6 mm., spire height 10.4 mm. The shell may be narrower and more banded (pl. 7, fig. 2e). Length 19.2 mm., greater diameter 12.3 mm., spire height 10.1 mm. The first postembryonic whorl is light buff, last two whorls a dark shade of diamine brown banded on the penultimate with light buff, last whorl at and below the periphery banded with white. An extremely lined form (pl. 7, fig. 2f) has the first half of the penultimate whorl light buff spirally lined with ochraceous tawny, last whorl and a half light buff, spirally lined above the periphery with bone brown, base solid bone brown; impressed sutural band amber brown. A rare pattern (pl. 7, fig. 2g) is diamine brown, lined with pale gull gray.

ACHATINELLA APEXFULVA NIGRIPICTA var. 2

PLATE 2, FIGURES 1, 2; PLATE 7, FIGURES 5-6a

Area 48: **Manana-Waiawa Ridge**, locality 237g, elevation 1,750-1,800 feet, 2 dextral; 237h, elevation 1,500-1,700 feet, Meinecke, 1933.

Area 48A: **Manana-Waiawa Ridge**, locality 238a, elevation 1,750-1,900 feet; 238b elevation 1,800-1,850 feet, Meinecke, 1933 (figs. 4, 4a, p. 53).

The shells of area 48 differ from *A. a. nigripicta* in having very obese dextral shells with usually a white ground instead of a yellowish one. The usual form and color pattern of the shell (pl. 2, fig. 1) measures: Length 19.4 mm., greater diameter 13.5 mm., spire height 9.5 mm.; embryonic whorls white; postembryonic whorls white spirally banded and lined with a dark shade of diamine brown. An obese form (pl. 7, fig. 5) with a white ground and black banded postembryonic whorls measures: Length 20.3 mm., greater diameter 14.2 mm., spire height 9.8 mm.

In area 48a the color patterns are close to those of area 48. The form of the shells shows no variation from those of area 50. The darkest pattern (pl. 7, fig. 6a) has the postembryonic whorls colored a dark shade of diamine brown, last whorls banded and lined at and below the periphery with pale pinkish cinnamon. A lined color pattern (pl. 7, fig. 6) has the postembryonic whorls white tinted with light buff, lined with verona brown and black, subperipheral band white, below which are two bands of black, in the umbilical region a band of warm buff. The usual light color pattern (pl. 2, fig. 2) has the postembryonic whorls white, lined on the last two whorls just above the periphery with a line of mikado brown, at and below the periphery lined and banded with black.

ACHATINELLA APEXFULVA SIMULACRUM Pilsbry and Cooke

PLATE 1, FIGURE 50; PLATE 7, FIGURES 13-15a

Achatinella turgida simulacrum PILSBRY and COOKE, Man. Conch., vol. 22, p. 299, pl. 56, figs. 14-14d (only), 1914.

The shell figured on plate 56, figure 14a, of the Manual of Conchology is considered the lectotype of *A. a. simulacrum* and is reproduced in this paper on plate 7, figure 13. The embryonic whorls are a light shade of cartridge buff, banded on the last half embryonic whorl with a faint color of warm buff; postembryonic whorls upper half white, lower half amber brown streaked and lined with chestnut,

at the edge of the periphery of the last whorl a band of white, below the periphery a wide band of hessian brown, and a band of white lined with hessian brown, and a band of antimony yellow; impressed sutural band white; lip and columella callus vinaceous fawn. Length 18.9 mm., greater diameter 13.0 mm., spire height 9.5 mm., number of whorls 6.

Distribution, area 46: **Waimano-Manana Ridge**, locality 227a, elevation 1,550 feet, 1 sinistral 1933; 227b, elevation 1,600 feet, 3 sinistral 1933; 227c, elevation 1,700 feet, 3 sinistral 1933; 228*, elevation 1,550-1,700 feet, 1929; 228a, elevation 1,750 feet, 1933; 229*, elevation 1,750-1,800 feet, 1929; 229a, elevation 1,600 feet, 4 sinistral 1933, all Meinecke-collected (figs. 4, 4a, p. 53). This area also collected by H. Lenke. Lectotype, ANSP 108063. Type locality, "Waimano-Manana ridge, along the summit trail, above the locality of *A. t. cookei* (Spalding, Pilsbry, Merriam), types 108063 A.N.S." (Pilsbry and Cooke, 1914).

The type locality was probably somewhere in the region of localities 228 and 228a. The usual color pattern and form of the shell (pl. 1, fig. 50) from these localities, has the embryonic whorls pale pinkish buff shading to cream color; postembryonic whorls white with a band of ochraceous tawny just above the edge of the periphery, which band is lined with white, last whorl below the white peripheral or subperipheral band warm blackish brown with three bands of pale pinkish buff at the edge of the aperture; lip and columella callus vinaceous fawn. Length 19.6 mm., greater diameter 13.5 mm., spire height 9.5 mm., number of whorls $6\frac{1}{4}$.

The usual narrow form of the shell (pl. 7, fig. 14) is banded and has a color pattern resembling plate 1, figure 50, except that the last whorl is more completely banded on the base with pale pinkish buff. Length 19.4 mm., greater diameter 12.5 mm., spire height 9.6 mm.

An elongate form (pl. 7, fig. 14a) has the spire ochraceous tawny; the impressed sutural and subsutural bands white; last postembryonic whorl below the white peripheral band pale pinkish buff, banded with warm blackish brown. Length 20.7 mm., greater diameter 12.5 mm., spire height 10.2 mm. The shell may lack a wide tawny band (pl. 7, fig. 15) and be banded just above the edge of the periphery and all below with warm blackish brown, above which is a line of ochraceous tawny, remainder of the shell white. A white color pattern (pl. 7, fig. 15a) has the postembryonic whorls white, banded and lined with ochraceous tawny, last fourth whorl banded with black.

ACHATINELLA APEXFULVA SIMULACRUM var. 1

PLATE 5, FIGURE 26

Area 38: **Central Waimano-North Central Waimano Ridge**, locality 212A, elevation 1,200-1,300 feet, 1 live sinistral, Meinecke, 1933; **North Central Waimano-North Waimano Ridge**, locality 215B, elevation 1,450 feet; 216B, elevation 1,450 feet; 218B, elevation 1,600-1,650 feet, 1 live sinistral, all Meinecke-collected, 1933 (figs. 4, 4a, p. 53). Since only two live shells are known from this area the range of color patterns is not known.

The shells are light color forms very similar to *A. a. simulacrum*, but differ in not having any dark-banded color patterns similar to plate 7, figure 13. A color pattern (pl. 5, fig. 26) common to the two live shells has the postembryonic whorls white spirally banded with tawny, base pale pinkish buff tinted with massicot yellow; lip not formed.

ACHATINELLA APEXFULVA RUBIDILINEA, new subspecies

PLATE 1, FIGURE 51; PLATE 7, FIGURES 16-18

The shell of the holotype (pl. 1, fig. 51) has the embryonic whorls white; postembryonic whorls white profusely lined with chocolate; impressed sutural band russet; lip and columella callus light vinaceous fawn. Length 20.7 mm., greater diameter 14.0 mm., spire height 10.1 mm.

Distribution, area 47: **Manana-Waiawa Ridge**, type locality 239a, elevation 2,000-2,050 feet, Meinecke, 1933; also 239b, elevation 2,050-2,250 feet, 6 sinistral; 239c, elevation 2,100-2,300 feet, 1 sinistral, Meinecke, 1933; **North Central Waimano-North Waimano Ridge**, locality 219B, elevation 1,850-1,900 feet, 8 sinistral, Meinecke, 1933; **Waimano-Manana Ridge**, locality 220A?, Meinecke, 1929 (figs. 4, 4a, p. 53).

The form of the holotype may not be the usual shape of the shell. Only seven adult specimens are had from the type locality, so a shell that appears to be the most usual form and having the characteristic color pattern is chosen for the holotype. The color pattern on a narrow shell is lighter (pl. 7, fig. 18), entire shell white; banded on the first postembryonic whorl just above the periphery with russet, shading to mars brown, on the penultimate, last whorl lined above the periphery with cinnamon buff, below the periphery with chocolate. Length 20.2 mm., greater diameter 12.8 mm., spire height 10.2 mm.

Each locality on a different ridge has shells with color patterns showing a slightly different arrangement of bands and lines. The form

also shows a great range. All the shells of area 47, however, are reddish-brown lined or banded shells, and the ground color is usually pure white. The shells are the next race occurring above *A. a. simulacrum*.

In locality 219B the usual form of the shell (pl. 7, fig. 16) has the postembryonic whorls white tinted on the last whorl with pinkish buff, banded on the last two whorls with chocolate. Length 19.1 mm., greater diameter 13.3 mm., spire height 9.5 mm. An obese specimen (pl. 7, fig. 16a) measures: Length 20.5 mm., greater diameter 14.0 mm., spire height 10.9 mm. It has the lightest color pattern, which is white lined with chocolate and tawny.

The region of locality 220A? has dark banded forms such as plate 7, figures 17 and 17a, which are banded or lined with chocolate, or light forms which are banded and lined with kaiser brown (pl. 7, figs. 17b, 17c). The extreme obese form (pl. 7, fig. 17) measures: Length 20.6 mm., greater diameter 14.2 mm., spire height 9.7 mm. A narrow shell, figure 17b, measures: Length 19.1 mm., greater diameter 12.7 mm., spire height 10.2 mm.

ACHATINELLA APEXFULVA CHROMATACME Pilsbry and Cooke

PLATE I, FIGURE 53; PLATE 6, FIGURES 20-23b

Achatinella swiftii chromatacme PILSBRY and COOKE, Man. Conch., vol. 22, p. 316, pl. 59, figs. 5-5b, 1914.

The subspecies *A. a. chromatacme* is closely related to *A. a. perplexa*, differing mainly in having dark-colored embryonic whorls, tan or yellowish-brown color patterns that do not occur in area 40, and the usual form having a wide light-colored band at the edge of the periphery. In rare cases the embryonic whorls may be white (pl. 6, fig. 22a), and the shell looks very much like a form of *A. a. perplexa*.

The shell of plate 59, figure 5, of the Manual of Conchology is selected by Pilsbry and myself for the lectotype of *A. a. chromatacme* and is reproduced in this paper on plate 6, figure 20. The first embryonic whorl of the lectotype is pinkish buff shading on the next whorl to cinnamon, which lightens on the upper half of the last embryonic whorl to pinkish buff; first postembryonic whorl, upper half pinkish buff lined with sayal brown, lower half sayal brown, penultimate whorl, upper half pinkish buff, lower half ecru drab axially streaked with rood's brown, last whorl above the white peripheral band vandyke brown darkening to bister, axially streaked with ecru drab, below the periphery warm sepia axially streaked with chocolate; impressed sutural band pinkish buff; lip margin army

brown; columella callus light vinaceous fawn. Length 20.1 mm., greater diameter 13.1 mm., spire height 11.1 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 42: **Manana-Waiawa Ridge**, locality 232, elevation 1,250 feet, 1929, 3 sinistral 1933; 233, elevation 1,350 feet, 1 dextral, 6 sinistral 1929; 234*, elevation 1,150-1,250 feet, 1929; 235*, elevation 1,150-1,250 feet, 1929; 236*, elevation 1,050-1,150 feet, 1929, all collected by Meinecke (figs. 4, 4a, p. 53). Lectotype, ANSP 108804, collected in **Waiawa** by Kuhns for Thaanum. Meinecke did a great deal of collecting with Kuhns and is familiar with Kuhn's localities. One or several of the above lots surely represents a series from the type locality. Meinecke, BBM 121835-121836, also reports this form from locality 230B?, elevation 1,000-1,150 feet, on the North-South Waiawa Ridge, 1929, but I am inclined to believe that the locality is wrongly plotted because of the wide difference between the color pattern of the shells of 230B* and the adjacent localities of 231B* and 232B*.

The exact region of the type locality is not known to me, so I have selected locality 235 for a typical one, and shall describe the color and size variation of the shells from that place. In the usual form of the shell (pl. 6, fig. 21) and a color pattern occurring on 53 percent of the shells, the embryonic whorls shade from pale pinkish buff to tawny, last embryonic whorl banded at the suture with white; on the first postembryonic whorl and a half the impressed sutural band shades from mikado brown to cinnamon, subsutural band extending to about the middle of the whorl above the periphery, shades from cinnamon buff to cinnamon, remainder of the whorl drab axially streaked with cinnamon, last whorl and a half, impressed sutural and narrow subsutural bands cinnamon, remainder of the whorl pinkish buff closely axially streaked and finely spirally lined with drab, so that the color looks at first glance to be solid drab, at the periphery a line and a band of pale pinkish buff; lip and columella callus light vinaceous fawn. Length 19.5 mm., greater diameter 13.2 mm., spire height 10.5 mm. A narrow shell (pl. 6, fig. 21a) shows the darkest color form of the brownish or tan color patterns; the postembryonic whorls shade from walnut brown to burnt umber axially streaked with light buff; impressed sutural band light buff. Length 19.7 mm., greater diameter 12.7 mm., spire height 11.0 mm.

Forty-seven percent of the live shells in locality 235 have a gray color pattern (pl. 6, fig. 21b); the embryonic whorls shade from pale pinkish buff to russet; first postembryonic whorl shades from sayal

brown to verona brown, penultimate whorl benzo brown axially streaked with pale drab gray, last whorl drab axially streaked with pale drab gray; impressed sutural and subsutural bands white; lip and columella callus light vinaceous fawn. Length 19.1 mm., greater diameter 13.7 mm., spire height 10.0 mm. The gray pattern may be lighter (pl. 6, fig. 21*c*); postembryonic whorls white, banded on the last whorl and a half above the periphery with benzo brown, pale drab gray, and on the last fourth whorl natal brown, which bands are axially streaked with white, last whorl below the white peripheral band natal brown, axially streaked with drab and drab gray, in the umbilical region a patch of white.

Below locality 235, in localities 232, 233, 234, the brown pattern is more prevalent, and usually of a lighter color than the usual brown color pattern in locality 235. Gray color patterns are rare in these lower localities, occurring on one or two specimens in each lot; dextrals are also unusual. In the usual form and color pattern (pl. 1, fig. 53), the embryonic whorls shade from pale pinkish buff to light buff to pale pinkish buff; postembryonic whorls shade from light buff to warm buff, spirally lined with white, banded at the periphery with a line of snuff brown, and a band of white, base banded with saccardo's umber and pale pinkish buff; lip and columella callus light vinaceous fawn. Length 19.3 mm., greater diameter 12.5 mm., spire height 10.6 mm. The usual obese form (pl. 6, fig. 23) measures: Length 19.7 mm., greater diameter 13.0 mm., spire height 11.1 mm.; postembryonic whorls ochraceous tawny, base saccardo's umber tinted with ochraceous tawny. An elongate specimen (pl. 6, fig. 23*a*) measures: Length 19.4 mm., greater diameter 12.2 mm., spire height 11.5 mm.; postembryonic whorls light ochraceous buff with a central band of light brownish olive, last whorl banded above and below the cartridge buff peripheral band with light brownish olive. A rare purplish pattern (pl. 6, fig. 23*b*) has the last two whorls dark vinaceous brown, axially streaked with white, peripheral band on last whorl white; sutural and subsutural bands white.

Another common pattern in area 42 is a streaked form (pl. 6, fig. 22); the postembryonic whorls, below the subsutural and impressed sutural bands of light buff, are snuff brown axially streaked with light buff, peripheral band on last whorl pale pinkish cinnamon. The lightest color pattern (pl. 6, fig. 22*a*), and an unusual specimen in that the embryonic whorls are pale pinkish buff and not darker, has the postembryonic whorls white, last whorl lined at the edge of the periphery with a faint line of sayal brown, banded below the periphery with hair brown bands which are streaked with white.

ACHATINELLA APEXFULVA CHROMATACME var. I

PLATE I, FIGURE 52; PLATE 6, FIGURES 24-24f

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 315, pl. 59, figs. 4b, 4c (only), 1914. (While these two shells are not typically *A. a. chromatacme* var. I, they are very close to it in color pattern.)

Area 4I: Manana-Waiawa Ridge, locality 230*, elevation 1,050-1,150 feet, 5 sinistral, 1929; 231*, elevation 1,000-1,100 feet; 230A*, elevation 1,050-1,100 feet, 3 dextral, 1 sinistral 1929; 231A*, elevation 750-800 feet, 12 dextral 1929; 232A, elevation 550-600 feet, 1 dextral, 2 sinistral 1933, all Meinecke-collected (figs. 4, 4a, p. 53).

The shells of area 4I can easily be confused with the shells of area 40 because the embryonic whorls may be white and the color pattern similar to *A. a. perplexa*. They have been considered a variety of *A. a. chromatacme* because some of the shells have dark embryonic whorls and the range of color patterns is closer to *A. a. chromatacme* than to *A. a. perplexa*. The form is characterized by most of the patterns being spirally lined with white.

The usual form (pl. I, fig. 52) has the first embryonic whorl pale pinkish buff, next whorl pinkish buff, last half embryonic whorl pinkish cinnamon with a central line of cinnamon; first postembryonic whorl pale pinkish buff lined with cinnamon, penultimate whorl benzo brown lined with pale pinkish buff, last whorl hair brown lined with white; impressed sutural band white, tinted pinkish buff; lip and columella callus light vinaceous fawn. Length 18.7 mm., greater diameter 12.2 mm., spire height 9.5 mm. The color pattern may be less lined (pl. 6, fig. 24) and look like *A. a. chromatacme*, first embryonic whorl and a half pale pinkish buff shading to tawny on the last embryonic whorl; postembryonic whorls pinkish buff, first postembryonic whorl axially streaked with cinnamon drab, and lined with the ground color, last two whorls lined and streaked with hair brown.

The dominant color pattern on 25 percent of the shells is a white lined pattern (pl. 6, fig. 24a); the postembryonic whorls white, first two faintly lined with mikado brown, last whorl a line of cinnamon above the periphery, at and below the periphery lined with sepia. The bands and lines may be axially streaked with white (pl. 6, fig. 24b); the shell is entirely white spirally lined with light drab, below the periphery of the last whorl a band of hair brown.

Lined brownish forms also occur. The lightest brown pattern (pl. 6, fig. 24c) has the first postembryonic whorl ochraceous tawny, with a central line of pale pinkish buff, on the penultimate and last

whorl above the periphery sutural and subsutural bands ochraceous tawny, below which is a thin band of pale pinkish buff, remainder of the whorl ochraceous tawny streaked with snuff brown, last whorl below the periphery pale pinkish buff, spirally lined with snuff brown. This specimen also shows an obese shell; length 19.1 mm., greater diameter 12.8 mm., spire height 10.1 mm. A narrow shell and dark brown color pattern (pl. 6, fig. 24*d*) has the penultimate whorl burnt umber finely lined and streaked with tilleul buff, last whorl bister axially streaked and spirally lined with snuff brown, and lined with pale pinkish buff. Length 18.6 mm., greater diameter 11.7 mm., spire height 10.3 mm.

Plate 6, figure 24*e* is a light gray pattern and obese form of a dextral shell; the postembryonic whorls pale pinkish cinnamon, the lower half of the first half postembryonic whorl dotted with cinnamon, penultimate whorl banded on the lower half of the whorl with a band of light drab shading to benzo brown axially streaked with pale pinkish buff, last whorl light drab gray with a wide sutural and subsutural band of pale pinkish buff, and a white peripheral band. Plate 6, figure 24*f*, is a narrow dextral with a color pattern similar to figure 24*d*, only the impressed sutural band is tawny.

ACHATINELLA APEXFULVA CHROMATACME var. 2

PLATE 1, FIGURE 54; PLATE 8, FIGURES 16, 16*a*

Area 43: **Manana-Waiawa Ridge**, locality 237*, elevation 1,100-1,200 feet, 1929; 237*a*, elevation 1,400-1,450 feet, 1933; 237*ba*, elevation 1,300-1,400 feet, 1933, all Meinecke-collected (figs. 4, 4*a*, p. 53).

This race is of interest because it occurs between *chromatacme* and *nigripicta*. The shells are definitely more lined and have more white color pattern than *chromatacme* and one would suppose they were intermediate between a white-lined race and *A. a. chromatacme*. But above area 43 the shells have mostly a yellowish ground and are banded with warm blackish brown or liver brown. The color patterns in area 43 are so close to *A. a. chromatacme* that I think it inadvisable to separate them, although the embryonic whorls are usually light colored similar to *A. a. perplexa*.

In the usual form (pl. 8, fig. 16) the embryonic whorls shade from pale pinkish buff to light buff; postembryonic whorls pale pinkish buff spirally lined and axially streaked with light buff, last whorl and a half just above and all below the periphery warm sepia axially streaked and spirally lined with warm buff; lip and columella callus light brownish vinaceous. Length 19.1 mm., greater diameter 12.8 mm., spire height 10.4 mm.

The usual color pattern and obese form of the shell is shown on plate 1, figure 54, postembryonic whorls white; impressed sutural band on the first postembryonic whorl light pinkish cinnamon, on the remaining whorls the pinkish cinnamon color is confined to the upper edge of the band and fades out on the last whorl; last whorl banded above the periphery with hair brown, below the periphery hair brown streaked with white and lined with natal brown. Length 17.6 mm., greater diameter 13.7 mm., spire height 8.6 mm. The embryonic whorls may be darker and the postembryonic whorls lighter (pl. 8, fig. 16a); embryonic whorls pale pinkish buff shading to ochraceous buff, banded at the suture on the last embryonic whorl with sayal brown; first postembryonic whorl snuff brown lined with white, penultimate whorl white, banded and lined with sayal brown, last whorl white, lined with sayal brown and banded below the periphery with warm sepia; impressed sutural band verona brown fading out to sayal brown on the last half whorl where it occupies only the upper edge of the sutural band.

ACHATINELLA APEXFULVA ALBIPRAETEXTA, new subspecies

PLATE 2, FIGURE 3; PLATE 8, FIGURES 18-21

The shell is closely related to *A. a. chromatacme*, but differs in the gray banding of the postembryonic whorls, and by having white embryonic whorls. The embryonic whorls of the holotype (pl. 2, fig. 3) are white; first postembryonic whorl white, lined with russet; on the last two whorls the impressed sutural and wide subsutural bands are white, except on the last half whorl, where the lower edge of the sutural band is edged with a line of wood brown; the remainder of the shell shades from brownish drab on the first half of the penultimate to drab gray axially darkened by streaks of light drab on the remaining whorls; lip vinaceous fawn. Length 18.0 mm., greater diameter 12.5 mm., spire height 9.3 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 63?: North-South Waiawa Ridge, type locality 231B*, elevation 1,000-1,100 feet, 1929; also locality 232B*, elevation 750-850 feet, Meinecke, 1929. The Meinecke localities were plotted in 1933 and may be plotted too low and should be checked. Also collected in Waiawa by Thurston, BBM 130590.

Area 64: South Waiawa Stream, locality 237A-1*, elevation 750-850 feet, 3 sinistral, H. Lemke, 1932; on a spur ridge of the North-South Waiawa Ridge, locality 233B-1*, elevation 1,350-1,400 feet, H. Lemke and H. Lemke, Jr., 1932. Area 63? is possibly wrongly plotted and perhaps should be placed higher or nearer area 64 (figs. 4, 4a, p. 53).

The narrow form of the shell (pl. 8, fig. 19) measures: Length 18.4 mm., greater diameter 10.8 mm., spire height 10.2 mm.; the color pattern is similar to plate 2, figure 3. An obese shell (pl. 8, fig. 20) from locality 232B exhibits the tan color pattern, which occurs on 22 percent of the shells in the type locality; the embryonic whorls are white; postembryonic whorls ochraceous buff, last half of the penultimate and last whorl just above the periphery and below the periphery mouse gray axially streaked with ochraceous buff; impressed sutural band the color of the ground except on the first post-embryonic whorl, where it is tawny. Length 19.0 mm., greater diameter 13.0 mm., spire height 10.1 mm. Two specimens of this tan color pattern were found to have the entire sutural band russet.

A dextral shell from the Thurston collection is shown on plate 8, figure 21. The color pattern is similar to plate 2, figure 3.

In locality 233B-1*, 48 percent of the 13 dextral shells have a gray pattern similar to typical *A. a. albipraetexta*, except that the post-embryonic whorls are not banded with gray. One of these (pl. 8, fig. 18) has the embryonic whorls cartridge buff; first postembryonic whorl cream buff shading to white, lined on the first half of the whorl with tawny, the periphery faintly spirally banded or tinted with pale drab gray, below the periphery the color is drab or verona brown axially streaked with white, behind the edge of the lip is a band from 2 to 3 mm. wide of warm sepia. Plate 8, figure 18a, shows the tan color pattern that occurs on 52 percent of the dextral specimens, a color pattern similar to that of plate 8, figure 20.

Thirty-two percent of the shells in 233B-1* are sinistral and differ in the range of color patterns from the dextral shells in having lined color patterns. The postembryonic whorls of the gray pattern (pl. 8, fig. 18b) are white spirally lined or tinted on the last two whorls with pale drab gray, just above or at the periphery a line of snuff brown, last whorl below the periphery spirally banded with pale drab gray, in the umbilical region banded with drab, pale pinkish buff, and cinnamon. The tan pattern (pl. 8, fig. 18c) has the postembryonic whorls white or pale pinkish buff, finely axially streaked or tinted with pinkish buff, last whorl banded at the edge of the periphery with white, below the periphery, spirally lined and axially streaked with a light shade of sayal brown.

ACHATINELLA APEXFULVA GRISEIBASIS, new subspecies

PLATE 2, FIGURE 6; PLATE 8, FIGURES 17, 17a

The shell is close to *A. a. lemkei* but differs in color pattern. The embryonic whorls of the holotype (pl. 2, fig. 6) are white except for

a line of chamois on the lower portion of the whorl just above the periphery. This can best be seen under a low-power microscope. First postembryonic whorl white, banded on the upper half of the whorl with tawny, remaining whorls white, last whorl below the periphery benzo brown axially streaked with pale drab gray; lip and columella callus vinaceous buff. Length 17.5 mm., greater diameter 12.1 mm., spire height 9.2 mm., number of whorls 6.

Distribution, area 65??: **East Waiawa**, "Ridge W. of Engineer's camp, $\frac{1}{4}$ mi. mauka [toward the mountains] of the ditch trail from large koa tree down toward camp, on koa [*Acacia koa*], pua [*Osmanthus*], guava [*Psidium guajava*]," O. H. Emerson, BBM 103967, 1915; also J. S. Emerson, BBM 102248, 1915. The exact location is not known. The shells were surely found at a low elevation, because they were collected on trees that occur at a low elevation. Area 65?? may possibly be the approximate region of the type locality (fig. 4a, p. 53).

A variation of the typical pattern (pl. 8, fig. 17) is similar to *A. a. chromatacme* var. 2 (pl. 8, fig. 16a); first embryonic whorl white, tinted with army brown, next whorl white, faintly banded on the lower half of the whorl with cream buff; postembryonic whorls white, first half postembryonic whorl banded and streaked with ochraceous tawny, last whorl below the periphery banded with verona brown or snuff brown. The usual narrow form (pl. 8, fig. 17a) measures: Length 17.6 mm., greater diameter 11.4 mm., spire height 9.5 mm.; embryonic whorls white; first half postembryonic whorl tawny, finely lined with white, last half tawny, banded on the lower two-thirds of the whorl with sorghum brown, penultimate whorl white, banded on the first half of the whorl with sorghum brown, last half with only a line of sorghum brown lightening to sayal brown, last whorl above the periphery white, below the periphery verona brown, finely lined and axially streaked with pale pinkish cinnamon.

GROUP OF *A. A. POLYMORPHA* GULICK

ACHATINELLA APEXFULVA POLYMORPHA Gulick

PLATE 8, FIGURES 24-28a

Apex polymorpha GULICK, Proc. Zool. Soc. London, 1873, p. 81, pl. 10, fig. 5.

Apex neglectus SMITH, Proc. Zool. Soc. London, 1873, p. 78, pl. 9, fig. 22.

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 307, 310, 315, pl. 59, figs. 4, 4a, 4d, 6 (only), 1914.

The holotype (pl. 8, fig. 27) has the first embryonic whorl white, remaining two and a half embryonic whorls upper half white, lower

half chamois; first postembryonic whorl light buff, with a central line of cinnamon buff, on the penultimate whorl, the subsutural band light pinkish cinnamon, remainder of the whorl light brownish drab, faintly spirally lined and axially streaked with pale pinkish cinnamon, last whorl subsutural band avellaneous, below which is a line of cartridge buff, supraperipheral band pale pinkish buff axially streaked with brownish drab, basal band same color but also spirally lined with brownish drab, peripheral band cartridge buff; lip cinnamon shading to white within; columella callus white; impressed sutural band shades from cameo brown on the first two whorls to wood brown on the first half of the last whorl to cinnamon on the last half whorl. Length 16.8 mm., greater diameter 12.3 mm., spire height 8.4 mm., number of whorls 6.

Distribution, area 66??: **Waipio**, Gulick. Gulick also reports the subspecies from Ahonui, Kalaikoa, Wahiawa. The district of Waipio includes Waikakalaua and Kipapa Gulches. The holotype of *A. a. polymorpha* surely did not come from north of Kipapa Gulch as Gulick reports, because the range of color patterns of one race does not extend over several gulches, although the same pattern may be repeated in widely separated areas. The holotype probably came from lower Kipapa or Panihakea Gulch in the district of Waiawa because it is similar to the shells existing in that region today. I have tentatively plotted the possible region of the type locality, area 66??, on fig. 5a, p. 105. Holotype, MCZ 39901.

A specimen (pl. 8, fig. 28) with a color pattern similar to the holotype has the embryonic whorls pale pinkish buff, banded on the lower half of the last embryonic whorl with light buff, on the first embryonic whorl at the edge of the suture a line of benzo brown; postembryonic whorls pale pinkish buff, first postembryonic whorls spirally lined with wood brown, last two whorls banded with drab, the bands lined and streaked with cinnamon drab and benzo brown; impressed sutural band russet shading to tawny on the last whorl; lip, outer margin cinnamon buff, inner margin and columella callus white. Length 16.4 mm., greater diameter 11.7 mm., spire height 8.8 mm.

The color pattern on a sinistral shell (pl. 8, fig. 28a) is much lighter and shows an elongate specimen; the first embryonic whorl and a half bicolored, upper half white, lower half hair brown, remaining embryonic whorls white, banded on the lower fourth of the whorl with a faint shade of cream buff; postembryonic whorls avellaneous spirally lined, banded, and streaked with white; impressed sutural band snuff brown on the first whorl lightening to light pinkish cinnamon on the last two whorls; lip not formed.

In the small series of shells in the Gulick collection in the Bishop Museum that can safely be identified as *A. a. polymorpha*, the typical pattern is a rare one and the range of color patterns is not determined. Usually, in Waiawa where forms similar or closely related to *A. a. polymorpha* occur, such as *A. a. polymorpha* var. 1, *A. a. flavitincta*, and *A. a. lemkei* var. 1, the sutural band is tan or brown. Exceptions to this rule are the shells of plate 8, figures 22*b* and 22*c*, of *A. a. lemkei*. But these two shells may belong to a race occurring at a higher elevation than *A. a. lemkei*. Since rare tan patterns occur with the usual banded patterns in area 68 and 69, which are very similar to the color patterns of the shell described as *Apex neglectus* by Smith, I believe that *neglectus* is a rare light tan color form of *A. a. polymorpha*.

There are four specimens of *Apex neglecta* in the type lot in the British Museum. One specimen marked "x" by myself is considered the lectotype, because it agrees best with Smith's original figure reproduced in this paper on plate 8, figure 24. The lectotype (pl. 8, fig. 24) has the embryonic whorls cartridge buff banded on the last embryonic whorl on the lower half of the whorl with cream buff; first two postembryonic whorls finely lined with cinnamon buff, last whorl pale olive gray axially streaked and faintly lined with light olive gray; impressed sutural band shades from hazel to carob brown on the last two whorls; subsutural band on the last whorl cinnamon buff; lip and columella callus vinaceous fawn. Length 17.2 mm., greater diameter 12.0 mm., number of whorls 6. Another shell from the type lot (pl. 8, fig. 25) has a convex spire, and a color pattern similar to the lectotype.

A dextral specimen in the Gulick collection (pl. 8, fig. 26) has the embryonic whorls white; postembryonic whorls pale pinkish buff spirally banded and lined with cinnamon or cinnamon buff above the periphery; the impressed sutural band mikado brown.

ACHATINELLA APEXFULVA POLYMORPHA var. 1

PLATE 8, FIGURES 29, 29*a*

Area?: Waiawa, J. S. Emerson, BBM 102247, BBM 33312.

The usual color pattern of the shell (pl. 8, fig. 29) resembles *A. a. polymorpha* except that the banding is a lighter shade of gray, and the base is white; the shape of the last whorl is rounded and the base is not flattened. Upper half of the first embryonic whorl white, lower half cream color, remaining embryonic whorls white, banded on the lower fourth of the whorl with warm buff; first half postembryonic whorl white, last half pinkish buff, first half of the penultimate

whorl pinkish buff spirally lined with light drab, last half pale mouse gray, lined and streaked with light buff, last whorl below the impressed sutural band light buff, banded or lined with drab and cinnamon buff, just above and below the white peripheral band are two bands of smoke gray, which shade to wood brown on the last half whorl, base white faintly lined with smoke gray; impressed sutural band amber brown shading to tawny on the last whorl; lip and columella callus pale vinaceous pink. Length 18.0 mm., greater diameter 12.2 mm., spire height 10.0 mm., number of whorls 6.

Five sinistrals are found in lot BBM 102247 of 23 shells. The color pattern on a few shells differs from the usual one. The post-embryonic whorls may be white or pale pinkish buff (pl. 8, fig. 29a), lined on the first and penultimate whorls with fawn color or wood brown, last whorl banded at the edge of the periphery with fawn color, banded below the periphery with benzo brown axially streaked with pale pinkish buff.

ACHATINELLA APEXFULVA FLAVITINCTA, new subspecies

PLATE 2, FIGURE 7; PLATE 8, FIGURES 30-30b

The form is closely related to *A. a. polymorpha* but differs in having the last whorl lined with dark lines of reddish brown. Plate 8, figure 30a, looks like Smith's *Apex neglectus* (pl. 8, fig. 24), except for the embryonic whorls and the lined last half postembryonic whorl.

The holotype (pl. 2, fig. 7) has the embryonic whorls bicolored, first embryonic whorl upper half white, lower half walnut brown, remaining embryonic whorls white; first postembryonic whorl white, penultimate whorl white with a faint line of light olive gray on the lower half of the whorl, last whorl above the periphery white, finely lined, axially streaked or tinted with chamois and banded above the edge of the periphery with olive buff, below the periphery banded or tinted with pallid mouse gray and lined with line and a band of benzo brown or fuscous; impressed sutural band army brown on the first whorl, on the penultimate avellaneous, on the last whorl ochraceous tawny; lip light vinaceous fawn. Length 17.2 mm., greater diameter 11.3 mm., spire height 9.5 mm., number of whorls 6.

Distribution, area 69: **Waiawa-Panihakea Ridge**, type locality 230G*, elevation 1,200-1,250 feet, 1932; also 230Ga*, elevation 1,300 feet, 2 dextral, 1 sinistral, 1932; 231G, elevation 1,350-1,400 feet, 1932, 5 dextral 1933; 232G*, elevation 1,300-1,400 feet, 1932, all collected by Meinecke (figs. 4, 4a, p. 53).

The elongate form (pl. 8, fig. 30) and the usual lined color pattern which occurs on 28 percent of the shells measures: Length 17.3 mm.,

greater diameter 11.4 mm., spire height 9.6 mm., number of whorls 6; postembryonic whorls white, penultimate whorl banded above the periphery with light mouse gray, last whorl above the periphery light buff faintly lined with white, and a line of sayal brown on the first half of the whorl, 5 mm. behind the edge of the lip a streak or tinting of tawny down to the supraperipheral band of light grayish olive, last whorl banded at the periphery with white, below the periphery ground white colored with a band of light grayish olive, which is lined with two lines of fuscous; impressed sutural band changes from russet to avellaneous.

The obese form of the shell (pl. 8, fig. 30a) and a yellowish or light variant of the typical color pattern has the first postembryonic whorl and a half white, last postembryonic whorl and a half warm buff axially streaked and spirally lined with white below the periphery the ground is white or pale gull gray slightly tinted above the aperture, and at the beginning of the last half of the whorl with spots of warm buff, lined with warm sepia, on the last half of the whorl; impressed sutural band russet lightening to cinnamon buff on the last whorl. Length 16.2 mm., greater diameter 11.5 mm., spire height 8.1 mm.

The usual form of a sinistral (pl. 8, fig. 30b) and darker lined variation of the lined pattern measures: Length 17.8 mm., greater diameter 11.2 mm., spire height 10.1 mm.; postembryonic whorls cartridge buff, spirally lined and axially streaked on the first postembryonic whorl with cinnamon buff, penultimate and last whorls lined with bone brown, at the periphery banded with white, below the periphery the ground is white with a central band of bone brown which divides into three on the last half of the whorl; impressed sutural band tawny on the first whorl, on the remaining whorls cinnamon buff.

ACHATINELLA APEXFULVA LEMKEI, new subspecies

PLATE 2, FIGURE 5; PLATE 8, FIGURES 22-22C

The color pattern resembles *A. a. leucorraphe*, but differs in not having a white sutural band, and in having the spire tinted with yellow; first half embryonic whorl of the holotype (pl. 2, fig. 5) black, next half of whorl upper half white, lower half black, last two embryonic whorls upper half white, lower half chamois; first postembryonic whorl light buff, spirally lined with white, first half of the penultimate light buff axially streaked with cinnamon drab; the impressed sutural band on the first postembryonic whorl and a half tawny, on the last whorl and a half the sutural and subsutural

bands light buff, the remainder of the whorl hair brown, chaetura drab, or warm sepia, axially broken by straight and zigzag streaks of pale pinkish buff or white, edge of the periphery banded with white; lip and columella callus vinaceous fawn. Length 17.2 mm., greater diameter 12.0 mm., spire height 9.2 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 67?: North Waiawa Stream, locality 230E-1-2?, approximate elevation 1,050-1,900 feet, "ridge back of tunnel-man's house," found on lehua (*Metrosideros*), Lemke, 1933, also 1932. The exact location of this race must be checked. Different lots from the general region of area 67? contain varying proportions of different color patterns which indicates slightly different localities (figs. 4, 4a, p. 53).

The darkest color pattern (pl. 8, fig. 22) has the first postembryonic whorl light buff finely axially streaked or tinted with ochraceous tawny, impressed sutural band ochraceous tawny, last two whorls bone brown, streaked with zigzag lines of light buff, sutural and subsutural bands light buff axially streaked with ochraceous tawny on the penultimate whorl, on the last whorl light buff, last whorl banded at the edge of the periphery with white; lip and columella callus light vinaceous fawn.

The usual color pattern of a dextral shell (pl. 8, fig. 22a) has the first postembryonic whorl white, tinted with pinkish buff, sutural and subsutural bands ochraceous tawny, penultimate whorl between white and pale pinkish buff tinted and streaked with cinnamon buff, sutural and subsutural bands cinnamon buff, just above the edge of the periphery a band of benzo brown, streaked with zigzag lines of white, last whorl above the white peripheral band pale cinnamon pink tinted with pinkish buff, supraperipheral band and all below the periphery natal brown spirally lined and streaked with zigzag axial lines of pallid mouse gray and white.

I have a number of lots before me collected by Lemke at different times from the region of the type locality. Lot 110, Lemke collection, has seven specimens, all except one with the typical pattern of plate 2, figure 5. In connection with lot 173, Lemke collection, Lemke states that he collected over a wider range, going up a spur ridge to the top of a larger ridge from which the spur branched. In this lot 45 percent of the shells have the typical patterns of *A. a. lemkei*; the remainder have white, gray-lined color patterns which possibly come from a locality at a higher elevation (see pl. 8, figs. 22b, 22c). Although I am calling these two shells *A. a. lemkei*, they quite possibly belong to another race occurring above *lemkei*, the two forms not being mixed except at the border of an upper and lower area.

The shell of plate 8, figure 22*b*, is white, last two postembryonic whorls tinted with cinnamon buff and spirally banded with pale drab gray deepening on the last half whorl to light drab and hair brown, the bands axially broken with white. The spire may be almost entirely white (pl. 8, fig. 22*c*), banded with drab below the periphery, which bands are broken by axial streaks of white, the last whorl above the periphery has a few faint lines of cinnamon buff.

ACHATINELLA APEXFULVA LEMKEI var. 1

PLATE 8, FIGURES 23-23*b*

Area 68?: North Waiawa Stream, general region of locality 233Ga?, approximate elevation 1,300 feet, Lemke, 1932, on lehua (*Metrosideros*), pua (*Osmanthus*), alani (*Pelea*) (figs. 4, 4*a*, p. 53).

The locality is a wide one and extends up to locality 234G on the Waiawa-Panihakea Ridge. The lots represent a mixture of two races, *A. a. lemkei* var. 1 and *A. a. lineipicta*. Color patterns similar to those found in locality 234G (*A. a. lineipicta*) are found mixed with color patterns not occurring in locality 234G. For discussion I shall take lot 113, Lemke collection, and describe only the unusual patterns which markedly differ from locality 234G, and occur on 48 percent of the shells.

The usual form (pl. 8, fig. 23) and color pattern of the shell has the embryonic whorls bicolored, first half embryonic whorl natal brown, shading to white on the upper fourth of the whorl, next half whorl upper half white, lower half pale drab gray, remaining embryonic whorls white banded with honey yellow just above the edge of the periphery; first postembryonic whorl light buff spirally lined with tawny; impressed sutural band tawny; remaining postembryonic whorls light buff finely lined and axially streaked with tawny, banded on the lower edge of the penultimate whorl with bone brown, last whorl below the periphery light buff, closely axially streaked, spirally lined and banded with bone brown; impressed sutural band on last two whorls light buff; lip and columella callus vinaceous fawn. Length 17.5 mm., greater diameter 12.1 mm., spire height 8.9 mm., number of whorls 6.

The color pattern may be darker (pl. 8, fig. 23*a*), the first half of the penultimate whorl russet axially streaked with tawny, last whorl and a half light buff almost entirely covered over by spiral lines and axial streaks of fuscous or carob brown; impressed sutural band light buff lined with tawny. An obese shell (pl. 8, fig. 23*b*), length 18.7 mm., greater diameter 13.5 mm., spire height 8.9 mm.,

number of whorls $6\frac{1}{2}$, has the postembryonic whorls light buff axially streaked with cinnamon buff; impressed sutural band on the first postembryonic whorl and a half tawny, on the remaining whorls the sutural band has the ground color; just below the periphery of the last whorl a band of white, the remainder of the base warm sepia axially streaked with zigzag lines of light buff, the edge of the periphery and just above banded with a band of warm sepia broken by the ground color. This color pattern is very similar to the typical *lemkei* pattern (pl. 2, fig. 5) except that the spire is yellow and not banded or streaked with gray on the first half of the penultimate whorl.

Although *A. a. lemkei* and its variety are not well localized, as far as the material at hand is concerned, they are of great importance to the addition of the knowledge of shell variation. Not only is there a possibility of finding new color patterns and races at different elevations on the long major ridges of the Koolau Range, but also on short spur ridges local races may be found at different elevations.

ACHATINELLA APEXFULVA LINEIPICTA, new subspecies

PLATE 2, FIGURE 8; PLATE 8, FIGURES 1-3a

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 314, pl. 58, figs. 5-5b (only), 1914. Figure 5b matches *A. a. lemkei* var. 1 (pl. 8, fig. 23a) of area 68 which is an intermediate area between areas 67 and 70.

The shell is an intermediate lined form existing between the lower race of *A. a. flavitincta* (area 69) and the upper race of *A. a. cavaensis* var. 3 (area 52). The first embryonic whorl of the holotype (pl. 2, fig. 8) fawn color, remaining embryonic whorls upper third white, lower two-thirds cream buff darkening to chamois; first postembryonic whorl upper third banded with white, lower portion cinnamon buff on the first half of the whorl, last half pinkish buff lined with verona brown, last two whorls light buff above the periphery, lined with seal brown, last whorl below the periphery pale gull gray spirally banded with seal brown; impressed sutural band on first postembryonic whorl russet, on the remaining whorls light buff with a line of tawny at the lower edge of the band; lip and columella callus vinaceous fawn. Length 17.6 mm., greater diameter 12.3 mm., spire height 9.0 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 70: **Waiawa-Panihakea Ridge**, type locality 232Ga, elevation 1,350-1,450 feet, 1933; 233G*, elevation 1,350-1,450 feet, 1932; 234G, elevation 1,400-1,500 feet, 1933. All Meinicke-collected (figs. 4, 4a, p. 53).

The shell may be more obese and very lined (pl. 8, fig. 1), the first half embryonic whorl fuscous, next whorl upper half white, lower half light grayish olive fading to white on the last embryonic whorl and a half; the first postembryonic whorl and a half white, banded with mikado brown and lined with cinnamon buff, last postembryonic whorl and a half pale gull gray lined with black, above the periphery the ground is lined with cinnamon buff and tinted with pinkish buff; impressed sutural band russet up to the last whorl, where it fades to pinkish buff. Length 17.8 mm., greater diameter 12.8 mm., spire height 9.1 mm.

The spire may not be banded (pl. 8, fig. 1a), and the shell may be narrow, postembryonic whorls white shading to pale gull gray on the last two whorls, last whorl has a peripheral band of white, banded and lined below the periphery with fuscous. Length 17.4 mm., greater diameter 11.0 mm., spire height 9.9 mm.

Each locality in area 71 appears to have similar patterns to the type locality but the form and color pattern varies. A common form and color pattern (pl. 8, fig. 2), in locality 233G* measures: Length 18.4 mm., greater diameter 13.1 mm., spire height 9.2 mm.; first postembryonic whorl light buff, axially streaked with light buff, penultimate whorl pale pinkish buff shading to pale gull gray on the last whorl, last two whorls profusely banded and lined with seal brown.

In locality 234G the usual form and color pattern (pl. 8, fig. 3) measures: Length 17.8 mm., greater diameter 12.6 mm., spire height 9.9 mm.; postembryonic whorls white darkening to pale gull gray, last whorl spirally lined with seal brown or black, the lines above the periphery broken by axial streaks of pale gull gray and the ground tinted with light buff; impressed sutural band ochraceous tawny becoming a dilute shade of ochraceous tawny on the last whorl. In this locality a dark color pattern (pl. 8, fig. 3a) is found on a single specimen; first postembryonic whorl and a half light buff axially streaked with chamois and lined with seal brown on the latter half of the whorl, last whorl and a half seal brown, spirally banded and lined with light buff or white.

ACHATINELLA APEXFULVA LINEIPICTA var. 1

PLATE 2, FIGURE 10; PLATE 8, FIGURES 4, 5

Area 72: Panihakea-Kipapa Ridge, locality 242-2*, elevation 1,350-1,400 feet, 13 sinistral; 242-3*, elevation 1,500-1,550 feet, 7 dextral, Russ and Welch, 1934, region of the upper portion of area

71 and area 72, or locality 241-1-242-3?, Russ, 1931, BBM 134151 (figs. 4, 4a, p. 53).

Area 72 is not very accurately plotted on a map. All of Welch's material consists of dead shells. The Russ material covers a considerable area so that areas 72 and 71 overlap. However, from the material on hand the shells appear to be intermediate between the forms found in area 71 and 70. The usual pattern (pl. 2, fig. 10) has the embryonic whorls similar to *A. a. lineipicta*; the first post-embryonic whorl white, penultimate whorl white deepening in color to pale pinkish buff on the last whorl, last two whorls lined above the periphery with hair brown and fuscous, last whorl at and below the periphery pale gull gray spirally lined and banded with olive brown and mouse gray; impressed sutural band russet becoming dilute in color on the last half whorl.

A few specimens have a gray color pattern (pl. 8, fig. 4), last two postembryonic whorls pale gull gray finely axially streaked and spirally lined with light gull gray. A single dark specimen (pl. 8, fig. 5) from locality 242-2*, is white on the first postembryonic whorl, lightly axially streaked with raw sienna, on the penultimate whorl the subsutural band is warm buff axially streaked with sudan brown, the remainder of the whorl seal brown lined with warm buff, last whorl seal brown or black, subsutural band warm buff, lined with russet; impressed sutural band russet; lip light vinaceous fawn.

ACHATINELLA APEXFULVA FUMOSITINCTA, new subspecies

PLATE 2, FIGURE 9; PLATE 8, FIGURES 31, 31a; PLATE 9, FIGURE 1

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 314, pl. 58, figs. 4, 4a (only), 1914.

The shell has a color pattern similar to *A. a. polymorpha* var. 1 (pl. 8, fig. 29) only it lacks the characteristic white peripheral bands on the last whorl, differs in shape and has a different series of color patterns which usually have a ground of smoke gray. The first embryonic whorl of the holotype (pl. 2, fig. 9) cream buff, remaining embryonic whorls cartridge buff, banded on the lower half of the whorl with chamois; first postembryonic whorl white, banded just above the periphery with tawny; impressed sutural and subsutural bands light vinaceous drab; penultimate and last whorls light grayish olive, tinted by fine axial streaks of smoke gray, last whorl banded at the periphery and about the base with smoke gray; impressed sutural band on the penultimate drab gray shading to avellaneous on the last whorl; lip and columella callus pale grayish vinaceous. Length

17.5 mm., greater diameter 12.5 mm., spire height 9.2 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 71: **Panihakea-Kipapa Ridge**, type locality 240*, elevation 1,300-1,350 feet, Meinecke, 1929; also locality 241-1a*, elevation 1,350-1,400 feet, 5 sinistral; 241-1*, elevation 1,250-1,450 feet; 241-2?, elevation 1,250-1,300 feet; 241-3*, elevation 1,300-1,350 feet, Welch and Russ, 1934; 240-1-241-1a?, elevation 1,400-1,450 feet, Russ; 241-1?, Russ, 1934; all localities approximately correct. Also collected by Cooke, 1911, BBM 22826-22828, 22832 (figs. 4, 4a, p. 53).

The typical pattern occurs on 78 percent of the shells in the type locality. One light gray shell (pl. 8, fig. 31) was found in the lot which also shows a narrow specimen. Length 16.6 mm., greater diameter 11.2 mm., spire height 8.5 mm. The first postembryonic whorl and a half are white, last whorl and a half pale mouse gray darkening to drab gray on the last half whorl, tinted above the periphery with pinkish buff, banded with white and faintly lined with benzo brown. Two specimens had a chocolate-lined pattern (pl. 8, fig. 31a); postembryonic whorls pale smoke gray spirally lined, banded, and finely axially streaked with chocolate; impressed sutural band chestnut. The typical pattern (pl. 9, fig. 1) may be lined and may lack the pronounced peripheral light gray band on the last whorl, last half of first whorl and first half of penultimate whorl smoke gray spirally lined and axially streaked with chocolate, last whorl and a half smoke gray spirally lined with light grayish olive, last half whorl streaked with fuscous, last whorl streaked with pale smoke gray.

GROUP OF *A. A. LEUCORRAPHE* GULICK

ACHATINELLA APEXFULVA LEUCORRAPHE Gulick

PLATE 9, FIGURES 2-4

Achatinella leucorraphe GULICK, Proc. Zool. Soc. London, 1873, p. 79, pl. 10, fig. 2.—PILSBRY and COOKE, Man. Conch., vol. 22, p. 301, pl. 59, fig. 8 (only), 1914.

The holotype (pl. 9, fig. 2) has the embryonic whorls bicolored, first two embryonic whorls and a half, upper half white, lower half hair brown or fuscous black, last embryonic whorl and a half white; first postembryonic whorl pale drab gray axially streaked with benzo brown, penultimate whorl pale drab gray axially streaked with zigzag streaks of fuscous, first half of last whorl white axially streaked with fuscous, and three streaks of dark vinaceous drab above the columella, last half of the whorl drab gray axially streaked with hair

brown; impressed sutural band white; lip and columella callus white. Length 19.0 mm., greater diameter 12.6 mm., spire height 10.2 mm., number of whorls $6\frac{1}{2}$.

Distribution, area?: **Kalaikoa**, Gulick. Holotype, MCZ 39903. **South Kaukonahua, South-Central Branch Ridge**, general region of locality 260A?, elevation? (fig. 5, p. 105), probably the lower portion of the locality, Meinecke, 2 sinistral 1928. Found mixed with *A. a. tuberosus* var. 4, BBM 121952. Also collected by Wilder, **South Kaukonahua Stream**, BBM 50573, 1 dextral, found mixed with *A. a. virgatifulva*, BBM 50572, and probably comes from the region of Waikakalaua Stream.

One of the Meinecke shells (pl. 9, fig. 3) has the first embryonic whorl slightly worn and colored army brown, remaining embryonic whorls upper two-thirds white, lower third benzo brown, the benzo brown fades out on the last half embryonic whorl; first postembryonic whorl white, axially streaked with light drab, penultimate whorl pale gull gray axially streaked with fuscous, last whorl spirally lined and axially streaked with seal brown and fuscous, ground color pale mouse gray, and sometimes appears as zigzag streaks of pale mouse gray between the darker axial coloration, last half whorl drab, axially streaked with seal brown and fuscous; lip and columella callus a dilute shade of pale vinaceous fawn; impressed sutural band white, lined on the last whorl with a line of fuscous on the lower portion of the band; the shell is not quite adult. Length 17.5 mm., greater diameter 12.1 mm., spire height 9.7 mm., number of whorls $6\frac{1}{4}$.

The other Meinecke shell (pl. 9, fig. 3a) has a pattern similar to that of *A. a. leucorraphe* on the first half of the penultimate whorl, while the remaining whorls look like some form of *A. a. tuberosus*. This shell (pl. 9, fig. 3a) has the first half postembryonic whorl white with a line of fawn color on the lower fourth of the whorl broken by axial streaks of white, next three-fourths of the whorl pale gull gray axially streaked with natal brown, next half whorl pale gull gray lined with natal brown, the lines broken by the ground color, last whorl darkening to drab on the last half, spirally lined and axially streaked with white or pale gull gray.

The Wilder specimen (pl. 9, fig. 4) differs from typical *leucorraphe* by having the embryonic whorls banded with yellow. The first embryonic whorl natal brown, next whorl upper fourth white, lower fourth natal brown shading to drab, last embryonic whorl shading from drab to honey yellow; first two postembryonic whorls and a fourth white, tinted on the penultimate with pale gull gray, last whorl pale gull gray axially streaked with benzo brown; lip light buff, columella callus white.

ACHATINELLA APEXFULVA VIRGATIFULVA, new subspecies

PLATE 2, FIGURE 16; PLATE 9, FIGURES 5-5c

Achatinella leucorraphe irvini PILSBRY and COOKE, Man. Conch., vol. 22, p. 304, pl. 59, figs. 14-14b (only), 1914.

The shell resembles *A. a. leucorraphe*, to which it is closely related, but differs from *leucorraphe* in having a brown sutural band, the embryonic whorls lined on the last half embryonic whorl with yellow, and the usual absence of zigzag streaks on the postembryonic whorls. The holotype (pl. 2, fig. 16) has the embryonic whorls bicolored; embryonic whorls white, banded on the lower third of the first embryonic whorl with natal brown, on the next whorl the band fading to fawn color and finally honey yellow on the last half embryonic whorl; postembryonic whorls pale pinkish cinnamon, axially streaked with natal brown and drab; impressed sutural band chestnut; lip and columella callus white faintly tinted with pale vinaceous fawn. Length 18.4 mm., greater diameter 12.2 mm., spire height 9.6 mm., number of whorls $6\frac{1}{4}$.

Distribution, area 73: **Waikakalaua Stream**, Wilder, BBM 50572, exact location of Wilder's type locality not known; **Kipapa-Waikakalaua Ridge**, locality 250A-2, elevation 1,050-1,100 feet, 3 sinistral, Lemke, 1936; **North Kipapa Gulch, first North Branch**, locality 240D-1a*, approximate elevation 900-1,000 feet, 2 dextral, Spalding, BBM 117384. Wilder's type locality probably came from somewhere in the region of localities 250A-2 and 240D-1a*. Area 73 is considered the probable distribution of the race. This race occurs at higher elevations but is usually not dominant and mixed with the lighter tan form of *A. a. virgatifulva* var. 2 (figs. 5, 5a, p. 105).

In the Wilder lot the typical color pattern occurs on 58 percent of the shells. A variation of this pattern, the lightest color pattern and the obese form of the shell (pl. 9, fig. 5), has the first half postembryonic whorl white, axially streaked with cinnamon buff, the remaining postembryonic whorls pinkish buff axially streaked with natal brown, army brown, and bone brown; impressed sutural band russet shading to tawny on the last whorl; lip tilleul buff. Length 17.5 mm., greater diameter 12.5 mm., spire height 9.6 mm.

An elongate specimen (pl. 9, fig. 5a) with the usual color of the darker color pattern occurring on 36 percent of the shells has the postembryonic whorls pinkish buff, heavily axially streaked with natal brown, the streaks broken by lines of pinkish buff; lip and columella callus white shading to light pinkish cinnamon at the outer edge. Length 19.2 mm., greater diameter 12.2 mm., spire height

11.0 mm. The darkest form of this darker color pattern (pl. 9, fig. 5*b*) is found on 5 specimens out of 26; first half postembryonic whorl cinnamon buff, lined with white, last half of the whorl russet, lined and streaked with pinkish buff, first three-fourths of the penultimate whorl chocolate, last fourth of penultimate and last whorl pinkish buff, spirally lined and heavily axially ornamented with closely set axial streaks of bone brown; impressed sutural band chestnut; lip and columella callus pale ochraceous buff.

On plate 9, figures 5*c* and 5*d* show the range of form of dextral specimens. Figure 5*c* has a color pattern similar to plate 9, figure 5. Length 17.7 mm., greater diameter 11.8 mm., spire height 9.8 mm., number of whorls $6\frac{1}{4}$. The shell of figure 5*d* has a color pattern occurring on 3 percent of the shells and looks like typical *A. a. leucorraphe* except for the brown sutural band; the last two and a half postembryonic whorls on this specimen have the first whorl white, and the last whorl and a half bone brown axially streaked and spirally lined with pale smoke gray or white. Length 17.3 mm., greater diameter 12.5 mm., spire height 8.8 mm., number of whorls $5\frac{1}{2}$.

On 3 percent of the shells the lined pattern of plate 9, figure 5*e* is found, the last two postembryonic whorls pale pinkish buff axially streaked with hair brown and spirally lined with fuscous, the lines broken by the ground color.

ACHATINELLA APEXFULVA VIRGATIFULVA var. 1

PLATE 2, FIGURE 20; PLATE 9, FIGURE 6

Area 75: Waikakalaua-South Kaukonahua Ridge, locality 260*, elevation 1,000-1,100 feet, Meinecke, BBM 121939, 3 dextral, 1 sinistral, 1932. Also collected by Thurston, BBM 130725, 14 sinistral, probably from area 75 (figs. 5, 5*a*, p. 105).

Only six shells are known from locality 260*. The shells have been separated out from area 73 because the axial streaks appear to be more closely set together and not as thick as in typical *A. a. virgatifulva*. But then certain specimens of the two areas resemble each other, so that I am undecided as to whether or not they are distinct subspecies.

A common color pattern from locality 260* on a juvenile specimen (pl. 2, fig. 20) has the embryonic whorls bicolored, upper half white, lower half honey yellow shading to chamois; first postembryonic whorl pale pinkish buff spirally lined and axially streaked with verona brown, last whorl and a half pinkish buff, finely axially streaked with olive brown and bone brown.

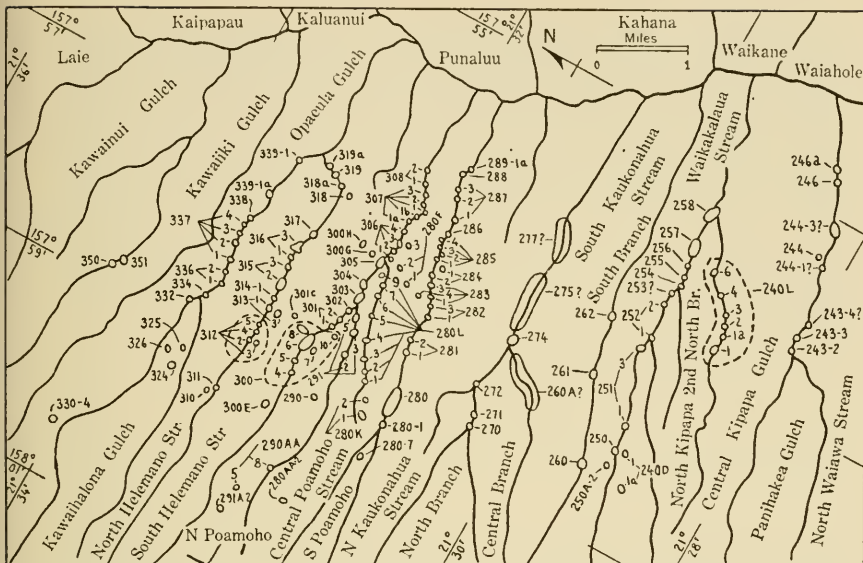


FIG. 5.—Northwest-central Oahu, leeward slope of the Koolau Range, comprising regions IIIb and most of regions III and IV (fig. 7, p. 194), showing localities of subspecies of *A. apexfulva* belonging to the groups of *A. a. polymorpha*, *A. a. irwini*, *A. a. leucorraphe*, *A. a. lilacea*, *A. a. apicata*, *A. a. aloha*, and *A. a. apexfulva*.

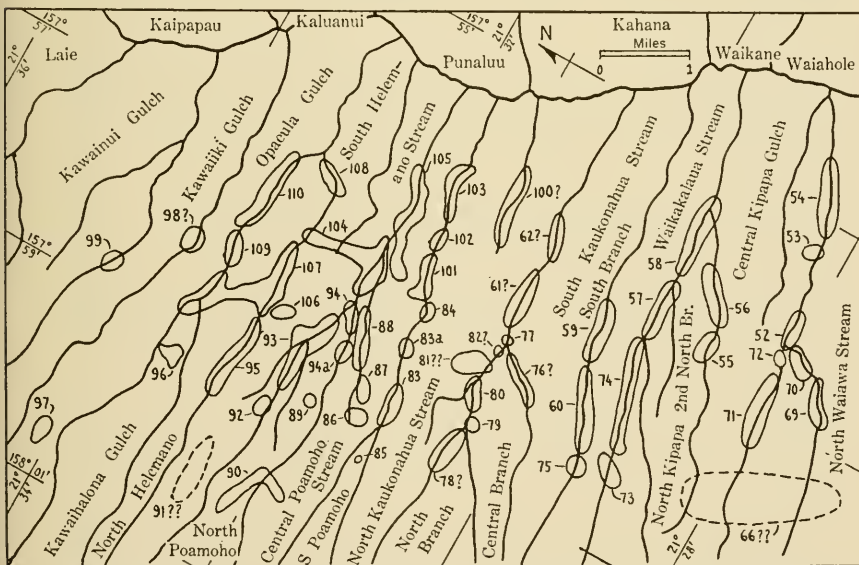


FIG. 5a.—Same as fig. 5, but showing the area occupied by different subspecies of *A. apexfulva* belonging to the groups of *A. a. polymorpha*, *A. a. irwini*, *A. a. leucorraphe*, *A. a. lilacea*, *A. a. apicata*, *A. a. aloha*, and *A. a. apexfulva*.

One of the Thurston shells (pl. 9, fig. 6) has the upper half of the first two embryonic whorls white, lower half natal brown or army brown, last embryonic whorl upper two-thirds white, lower third honey yellow; first postembryonic whorl pale pinkish buff, axially streaked with pinkish buff, first half of the penultimate whorl pale pinkish buff axially streaked with cinnamon buff, last half cinnamon buff axially streaked with mikado brown, last whorl cinnamon brown finely axially streaked with quaker drab and chocolate; impressed sutural band chestnut; lip and columella callus pale vinaceous fawn, lip outer edge light vinaceous cinnamon.

ACHATINELLA APEXFULVA VIRGATIFULVA var. 2

PLATE 2, FIGURE 17; PLATE 9, FIGURES 7-9

Achatinella leucorraphe irwini PILSBRY and COOKE, Mar. Conch., vol. 22, p. 305, pl. 59, fig. 13 (only), 1914.

Area 74: **North Kipapa Gulch, first North Branch**, locality 240D-1, elevation 950-1,000 feet, 2 dextral, Lemke, 1935; **Kipapa-Waikakalaua Ridge**, locality 251-1, elevation 1,300-1,350 feet, H. Lemke, 5 dextral 1933; 250*, elevation 1,200 feet, Meinecke, 1932; 251-1-3*, Russ, 1931; 251-3, elevation 1,500-1,600 feet, 6 dextral, Meinecke, 1933. Also collected by Spalding and Thurston (figs. 5, 5a, p. 105).

Shells with color patterns very similar to that of *A. a. virgatifulva* var. 2 are found in lots of shells from **Waikakalaua Stream**, Wilder, BBM 50571, and **South Kaukonahua Stream**, Wilder, BBM 50573 (probably the **Waikakalaua-South Kaukonahua Ridge**).

The shell is closely related to *A. a. virgatifulva*, but differs in having a light tan streaked color pattern instead of a dark brown streaked one, and a light impressed sutural band instead of a dark brown sutural band. Specimens of *A. a. virgatifulva* are usually mixed with this form. Although the color pattern is very distinct and the form is undoubtedly a distinct one, I shall consider it a variety of *A. a. virgatifulva* until a locality is found that contains shells of *A. a. virgatifulva* var. 2 not mixed with *A. a. virgatifulva*. Most of the localities at lower elevations in areas 74, 57, 75, and 60 are wide localities and little carefully plotted material is at my disposal from this section.

The usual form (pl. 2, fig. 17) of the light color pattern has the embryonic whorls bicolored, first embryonic whorl cinnamon drab, next whorl upper half white, lower half shaded with natal brown, on the last embryonic whorl the lower band fades out and the whorl is

white; the first postembryonic whorl and a half white or pale pinkish buff, axially streaked with pale pinkish buff, last whorl and a half pale pinkish buff axially streaked with vinaceous buff, avellaneous and wood brown, and spirally lined with pale pinkish buff; impressed sutural band same as the remainder of the whorl; lip and columella callus pale vinaceous fawn, outer edge of lip pinkish buff. Length 17.7 mm., greater diameter 12.3 mm., spire height 9.4 mm., number of whorls $6\frac{1}{4}$.

The obese form (pl. 9, fig. 7) and light color pattern has the postembryonic whorls white, penultimate and last whorls shaded by axial streaks of a dilute color of vinaceous buff. Length 18.5 mm., greater diameter 13.1 mm., spire height 9.4 mm., number of whorls 6. An elongate specimen (pl. 9, fig. 8) has the postembryonic whorls white shading to tilleul buff on the last whorl, last two whorls axially streaked with avellaneous. Length 17.7 mm., greater diameter 11.8 mm., spire height 9.8 mm.

In the Russ lot from the region of 250-251-3*, lined forms similar to plate 9, figure 8a, are found; the postembryonic whorls are white, penultimate faintly spirally lined or banded with cinnamon buff and sayal brown which are broken by axial streaks of white, last whorl spirally lined and banded with sayal brown and warm sepia, the lines and bands broken by axial streaks of white. This form is probably one from the upper edge of area 74 because it is similar to the form of *A. a. evaensis* var. 6 (pl. 8, fig. 7) found in locality 251-1-2.

This light color form may be sinistral (pl. 9, fig. 9); the postembryonic whorls a yellowish hue of vinaceous buff, axially streaked with white.

ACHATINELLA APEXFULVA TUBERANS Gulick

PLATE 9, FIGURE 12

Apex tuberans GULICK, Proc. Zool. Soc. London, 1873, p. 81, pl. 10, fig. 3.

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 313, 314, pl. 58, figs. 6, 9b, 11a? (only), 1914.

The holotype (pl. 9, fig. 12) in the Museum of Comparative Zoology has the embryonic whorls white, last embryonic whorl with a central band of cartridge buff; first postembryonic whorl cartridge buff, shading to tilleul buff on the last half of the whorl spirally banded on the lower fourth of the whorl with clay color darkening to benzo brown, penultimate whorl light mouse gray lined with mikado brown, benzo brown, last whorl below the white subsutural band, pale mouse gray axially streaked with light mouse gray, banded with

an upper band of mikado brown and a lower band of chocolate, peripheral band white, below the periphery white lined with mikado brown, sayal brown, and two bands of bone brown, below which is a band of sorghum brown; lip and columella callus tilleul buff; impressed sutural band shades from fawn color on the first half post-embryonic whorl to vinaceous buff on the next whorl and a half, on the last whorl white or tilleul buff. Length 19.6 mm., greater diameter 13.8 mm., spire height 10.5 mm., number of whorls 6.

Distribution, area?: **Kalaikoa**, Gulick. Also reported from Ahonui, Wahiawa, and Helemano by Gulick. These last three localities are probably erroneous.

The typical *A. a. tuberans* pattern is not plentiful in the Gulick collection. Out of 30 specimens in the Bishop Museum marked *A. tuberans* by Gulick coming from Kalaikoa and Ahonui, only six can be said to have a pattern closely simulating the pattern of the holotype. Quite probably Gulick obtained the few specimens of *A. a. tuberans* from an entirely different place from the remainder of his material and mixed them with shells from a different region. Typical *tuberans* has not been located in recent years but the forms collected today of *A. a. tuberans* are probably closer to typical *A. a. tuberans* than most of Gulick's specimens, which undoubtedly belong to a different colony and will be dealt with under *A. a. tuberans* var. 1. The type locality of the holotype probably was somewhere at a low elevation in South Kaukonahua Stream.

ACHATINELLA APEXFULVA TUBERANS var. 1

PLATE 9, FIGURES 13-13c

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 314, pl. 58, figs. 9, 9a (only), 1914.

Area?: **Kalaikoa**, Gulick. This area was probably somewhere at a low elevation in South Kaukonahua Stream.

The form is probably a race occurring near *A. a. flavida* because the ground color of so many specimens is yellow. The usual color pattern (pl. 9, fig. 13) on 45 percent of the shells has the embryonic whorls white; first postembryonic whorls white faintly axially streaked with pallid mouse gray, penultimate whorl white axially streaked and spirally lined with light mouse gray, last whorl above the periphery pale olive gray axially streaked and tinted with colonial buff and spirally lined or banded and axially streaked with natal brown, below the periphery the ground is colonial buff axially streaked and lined with dark livid brown; impressed sutural band vinaceous buff;

lip and columella callus white or a faint shade of pale vinaceous fawn. Length 18.0 mm., greater diameter 12.7 mm., spire height 9.8 mm., number of whorls $6\frac{1}{4}$. The usual form is not determined because of a lack of sufficient number of adult shells.

An obese shell (pl. 9, fig. 13a) and a variant of the usual pattern which does not have the lip fully developed, measures: Length 17.1 mm., greater diameter 13.5 mm., spire height 8.6 mm.; penultimate whorl white axially streaked with natal brown and spirally lined with white, last whorl chamois spirally banded and axially streaked with hay's brown above the periphery, the peripheral band is chamois axially streaked with avellaneous, below the periphery the subperipheral band is hay's brown, the remainder of the base is dark olive buff, lined and streaked with hay's brown. The light color pattern on 17 percent of the shells (pl. 9, fig. 13b) is similar to *A. a. versicolor* and has the last two whorls above the periphery white, axially streaked and spirally lined with vinaceous fawn color and army brown, on the last whorl below the periphery the ground is colonial buff spirally banded with hay's brown about the base and faintly axially streaked and spirally banded with light drab.

Thirty-eight percent of the shells have a pattern similar to that of plate 9, figure 13c, which shows a narrow shell; the first two post-embryonic whorls are pale smoke gray, spirally lined and streaked on the first postembryonic whorl with warm sepia, white, and cinnamon buff, penultimate whorl axially streaked with zigzag and straight streaks of natal brown and army brown, and spirally banded with a band of white below the suture and subsutural bands, last whorl drab gray axially streaked and lined with benzo brown and hair brown, and banded below the subsutural band and at the periphery with white, tinted with tilleul buff; the sutural and subsutural bands form a single wide band, which is natal brown axially streaked with white on the first half of the penultimate, and wood brown axially streaked with vinaceous buff on the last whorl and a half.

ACHATINELLA APEXFULVA TUBERANS var. 2

PLATE 2, FIGURE 21; PLATE 9, FIGURES 10-11a

Achatinella leucorraphe irwini PILSBRY and COOKE, Man. Conch., vol. 22, p. 304, pl. 59, fig. 9 (only), 1914.

Area 60: Waikakalaua-South Kaukonahua Ridge, locality 261*, approximate elevation 1,450-1,529 feet, 1932; 260-261?, approximate elevation 1,100-1,529 feet, Meinecke, 1913. Locality 261 may not be very accurately plotted but is probably somewhere between localities 260 and 261 (figs. 5, 5a, p. 105).

This race is apparently an intermediate between *virgatifulva* var. 1 (area 75) and *excaensis* var. 8 (area 59). This race usually occurs mixed with *A. a. excensis* var. 8, and I do not know whether it is a pure race or not. Probably the reason for the mixture is that all the collecting has been done over a wide area and the one locality that is not of wide extent may be a region where the two races overlap.

The usual color pattern (pl. 2, fig. 21) has the embryonic whorls bicolored; first half embryonic whorl hair brown, last half upper half white, lower half hair brown, next embryonic whorl and a half upper half white, lower half with two bands each covering a fourth of the whorl, the lower one benzo brown, the upper honey yellow, last half embryonic whorl upper half white, lower half chamois; first one-half postembryonic whorl white, with a line just above the edge of the periphery of chamois, next whorl white, lined with pinkish cinnamon, just above the edge of the periphery a line of verona brown, last whorl and a half white, shading to pale gull gray, spirally lined and banded with deep brownish drab; impressed sutural band white on the first postembryonic whorl and a half, on the last whorl and a half the color darkening from cartridge buff to tawny on the last whorl; lip and columella callus pale vinaceous fawn. Length 18.4 mm., greater diameter 12.2 mm., spire height 9.8 mm., number of whorls $6\frac{1}{8}$. The usual form is not determined because so few adult specimens of this race are at hand.

The color pattern varies. A dextral (pl. 9, fig. 10) has the post-embryonic whorls white, first half of last whorl banded above the periphery with a band of avellaneous and faintly axially streaked with tilleul buff, below the periphery the axial streaks deepening to vinaceous buff, last half whorl tilleul buff axially streaked with vinaceous buff, all below the periphery and just above the periphery the base is lined, banded closely, axially streaked with fine streaks of grayish olive and benzo brown, with a dark subperipheral band of mouse gray; impressed sutural band on the last two whorls tawny; subsutural band deep quaker drab. This specimen has the light streaking of the lower race and the gray banding of the upper race.

The color pattern may be lighter (pl. 9, fig. 11); first half of penultimate pale pinkish buff, spirally lined with cinnamon buff, last whorl and a half tilleul buff, spirally lined and axially streaked with wood brown and drab.

A specimen (pl. 9, fig. 11a) is found which has a pattern very similar to the typical *tuberans* pattern (pl. 9, fig. 12). The shell is not adult; first postembryonic whorl white, spirally lined with mikado

brown, last whorl and a half white, spirally lined with mouse gray, in the umbilical region a band of pinkish buff; impressed sutural band russet.

ACHATINELLA APEXFULVA TUBERANS var. 3

PLATE 2, FIGURE 28; PLATE 9, FIGURES 14-15

Area 77: **North-South Kaukonahua Ridge**, locality 274, elevation 1,600-1,747 feet, Lemke, 1932, Steel, 2 dextral 1934. Also collected by Wilder, BBM 10448, and O. H. Emerson, BBM 103971, probably in the region of area 77 (figs. 5, 5a, p. 105).

This form of *A. a. tuberans* resembles typical *tuberans* very closely in color pattern. None of the specimens, however, have on the last whorl the dark bands unbroken by axial streaks that are so characteristic of typical *tuberans*. Area 77 is an intermediate one between the subspecific group of *A. a. lilacea* and *A. a. leucorraphe* because there is a mixture of both kinds of embryonic whorls in the locality. A usual color pattern (pl. 2, fig. 28) has the embryonic whorls light buff, last embryonic whorl and a half banded on the upper half of the whorl with white; penultimate and last postembryonic whorl light mouse gray spirally lined and banded with white and axially streaked with dark livid brown and hair brown; impressed sutural band ochraceous tawny with a line of bone brown on the lower half of the band, on the last whorl the upper half of the band ochraceous tawny and the bone-brown line is in the center of the band, lower half light mouse gray axially streaked with dark livid brown; below the sutural band is a line of bone brown; lip and columella callus pale ochraceous fawn. Length 21.2 mm., greater diameter 14.2 mm., spire height 11.4 mm. The usual form of the shell is not shown by figure 28. The usual length of the shell is around 19.5 mm., and has a greater diameter of 12.5 or 13.5 mm.

The color pattern may be much lighter (pl. 9, fig. 14); embryonic whorls white; first two postembryonic whorls pale pinkish cinnamon spirally lined with tilleul buff on the upper half of the penultimate whorl, lower half banded smoke gray axially streaked with pale pinkish cinnamon or white, last whorl light drab darkening to hair brown on the last half whorl, axially streaked with benzo brown, drab, and white and spirally banded and lined with white; impressed sutural band tilleul buff; lip not formed; specimen not quite adult.

The shells of area 77 seem to be an intermediate race between lower *punicea* var. 1 and the higher race of *irwini*. The Lemke lot contains shells with unicolored embryonic whorls, but one specimen

(pl. 9, fig. 14a) in the lot has embryonic whorls similar to *A. a. irwini*. The embryonic whorls are bicolored, first embryonic whorl army brown, next embryonic whorl and a half upper half white, lower half natal brown, last three-fourths embryonic whorl chamois on the lower two-thirds of the whorl, upper third white; post-embryonic whorls drab gray spirally lined with white and dusky drab, and axially streaked with white, last half whorl above the periphery almost solid dusky drab, at the edge of the periphery a band of dusky drab, above and below which is a band of white.

The Wilder and O. H. Emerson shells probably came from near area 77, the usual length of the shell is 18.5 mm., and the usual color pattern (pl. 9, fig. 15) has the last two whorls white deepening to pale gull gray on the last whorl, spirally lined above the periphery with mouse gray, the peripheral band deep mouse gray, below the white subperipheral band, the base mouse gray spirally banded with benzo brown; impressed sutural band pinkish buff. Length 18.2 mm., greater diameter 12.8 mm., spire height 9.6 mm. The Wilder specimens consisting of two shells are selected from a mixed lot containing shells from a lower locality with a different color pattern.

ACHATINELLA APEXFULVA TUBERANS var. 4

PLATE 2, FIGURE 23; PLATE 9, FIGURES 16-16c

Achatinella leucorraphe irwini PILSBRY and COOKE, Man. Conch., vol. 22, p. 305, pl. 59, figs. 16-16b (only), 1914.

Area 76?: South Kaukonahua South-Central Branch Ridge in the general region of locality 260A?, approximate elevation 1,550-1,700 feet, Meinecke, BBM 121968, 1918, BBM 121952, 1924. Other collectors of this form are Wilder, BBM 10442, O. H. Emerson, BBM 103969, J. S. Emerson. The shells of area 76 are described from the Meinecke lot, BBM 121968 (figs. 5, 5a, p. 105).

The usual color form of the shell (pl. 2, fig. 23), lot BBM 121968, has the embryonic whorls bicolored, first half whorl army brown, next whorl and a half upper half pinkish buff, lower half army brown lightening to wood brown, next embryonic whorl pinkish buff lined with white, last half embryonic whorl white; first quarter post-embryonic whorl white, next quarter whorl light buff axially streaked with warm sepia, last half of the whorl and first half of penultimate warm buff spirally lined with and streaked with warm sepia, last half of penultimate and first half of last whorl warm buff faintly lined with wood brown and a line of fawn color, last whorl banded just above the edge of the periphery with a band of sepia axially streaked

with snuff brown, below which is a band of pinkish buff, base spirally banded with sepia and snuff brown; impressed sutural band warm sepia lightening to verona brown on the last whorl; lip vinaceous fawn; columella callus white. Length 18.0 mm., greater diameter 12.2 mm., spire height 10.2 mm.

Plate 9, figure 16, is a narrow specimen and light color pattern, the last two postembryonic whorls tiller buff spirally lined with natal brown on the penultimate and hair brown and drab gray above the periphery on the last whorl, base below the white subperipheral band drab, banded with buffy brown and lined with white; impressed sutural band wood brown darkening to cinnamon on the last whorl. Length 18.0 mm., greater diameter 11.6 mm., spire height 10.2 mm.

The usual dark color form (pl. 9, fig. 16a) has the first whorl vinaceous buff, axially streaked with army brown and natal brown, last whorl and a half below the sutural band pale gull gray, lined with hay's brown, with a suprapерipheral band of hay's brown axially streaked with deep olive buff, at the edge of the periphery a band of white, below the periphery the base is avellaneous axially streaked with hay's brown and spirally lined with white; impressed sutural band verona brown. Length 17.7 mm., greater diameter 13.0 mm., spire height 9.3 mm.

A variation of the dark color pattern (pl. 9, fig. 16b) found on two specimens has the last two postembryonic whorls pale pinkish buff axially streaked and spirally lined with hair brown and chaetura drab, last whorl lined at the periphery with two lines of white, ground color of the last half whorl drab gray; impressed sutural band russet.

One specimen (pl. 9, fig. 16c) is found to have a pattern similar to that of typical *A. a. tubersans*, except that the embryonic whorls are bicolored as in plate 2, figure 23; the last two whorls are pale gull gray spirally lined and banded with bone brown and natal brown, base on the last half whorl axially streaked with natal brown; impressed sutural band russet lightening to tawny on the last half whorl. One specimen similar to plate 9, figure 17c, is also found in this lot, differing only in that it has a peripheral yellow band.

ACHATINELLA APEXFULVA TUBERANS var. 5

PLATE 9, FIGURES 17-17e

Distribution, area?: **South Kaukonahua Stream, Wilder, BBM 50575.** This lot of shells may have come from somewhere near or along the South Kaukonahua South-Central Branch Ridge. However, no material from this ridge has been carefully localized and no accu-

rate information concerning distribution and variation has been available to me. Every lot of shells collected from the South Kaukonahua shows a different set of color patterns. Wilder's lot contained a mixture of *A. a. tuberosans* var. 4 patterns, which were mixed with decidedly smaller shells with a different range of color patterns. Therefore, the var. 4 patterns are selected out and the remaining shells are considered *tuberosans* var. 5, which may be the same or a lower race (fig. 5, p. 105). Also collected by Thurston, BBM 130737.

The usual form of the shell (pl. 9, fig. 17) has the embryonic whorls bicolored; first embryonic whorl natal brown, next whorl upper half white, lower half natal brown, last embryonic whorl and a fourth white; first half postembryonic whorl white, penultimate whorl axially streaked by straight and zigzag streaks of warm sepia and vinaceous buff, and spirally lined and banded with white, last whorl above the periphery ornamented with a band of white and a line of buffy brown and a band of vinaceous buff axially streaked with olive brown and hair brown, below the periphery the ground is white, banded with a band of bister and a band of drab axially streaked with olive brown; impressed sutural band mikado brown. Length 16.9 mm., greater diameter 11.6 mm., spire height 7.8 mm., number of whorls 6.

A narrow shell (pl. 9, fig. 17a) with lighter embryonic whorls, has a more usual color pattern which occurs on 34 percent of the shells, embryonic whorls bicolored, first embryonic whorl vinaceous buff, next whorl upper half white, lower half vinaceous buff, last embryonic whorl and a quarter white; first postembryonic whorl white spirally lined with army brown, last two whorls pale gull gray, penultimate whorl spirally lined and faintly axially streaked with fuscous, last whorl above the periphery banded with olive brown, the bands axially broken by streaks of pale gull gray, at the edge of the periphery a line of bister, below the periphery a band of pale gull gray, below this a line of bister and a band of drab axially streaked with natal brown, the remainder of the base banded with bister and drab; impressed sutural band chestnut lightening on the last half whorl to tawny. Length 16.6 mm., greater diameter 10.8 mm., spire height 9.2 mm.

The obese form (pl. 9, fig. 17b) and color pattern occurring on 28 percent of the shells has the last two postembryonic whorls white or pale gull gray spirally lined with natal brown and axially streaked with pale gull gray, just above the edge of the periphery to the edge of the periphery a band of light seal brown, base banded and

lined with natal brown; impressed sutural band vinaceous buff. Length 16.1 mm., greater diameter 11.8 mm., spire height 8.9 mm.

The lightest color pattern (pl. 9, fig. 17*c*) occurring on 31 percent of the shells has the postembryonic whorls white spirally lined on the last two whorls with light mouse gray and mouse gray, which lines are broken by axial streaks of white; impressed sutural band white, upper edge fawn color. This specimen also shows a sinistral shell. Four percent have a pattern similar to that of plate 9, figure 17*d*; postembryonic whorls white, last two whorls with a band of chocolate just above the edge of the periphery, just below the edge of the periphery a band of white, remainder of the base wood brown, lined and banded with natal brown. Two specimens in the lot of 75 shells have a color pattern resembling typical *A. a. apexfulva*. One of these (pl. 9, fig. 17*e*) has the first embryonic whorl army brown, next whorl upper two-thirds white, lower third natal brown, last embryonic whorl white; last two postembryonic whorls chocolate faintly axially streaked on the penultimate with orange cinnamon.

GROUP OF *A. a. IRWINI* PILSBRY AND COOKE

ACHATINELLA APEXFULVA EWAENSIS, new subspecies

PLATE 2, FIGURE 15; PLATE 7, FIGURES 23-24*a*

The shell is similar to *A. a. irwini* but differs in being smaller and having a characteristic series of reddish-brown banded color forms which differ entirely from *A. a. irwini*. The embryonic whorls of the shells of *A. a. ewaensis* and its varieties are usually banded with a deep shade of yellow such as dresden brown, chamois, or cinnamon buff. *A. a. irwini* and its varieties usually do not have the embryonic whorls banded with yellow. A few specimens of *A. a. irwini* do have the embryonic whorls banded with tints of yellow, such as cartridge buff and cream buff, but never intensely banded with yellow.

The embryonic whorls of the holotype (pl. 2, fig. 15) are bicolored, upper half white, lower half banded with dresden brown shading to buckthorn brown on the last embryonic whorl and a half; postembryonic whorls white faintly tinted with faint lines of pale gull gray, last whorl lined at and below the periphery with seal brown; lip and columella callus tinted with light brownish vinaceous. Length 17.0 mm., greater diameter 12.1 mm., spire height 8.5 mm., number of whorls 5½.

Distribution, area 56: **North-Central Kipapa Ridge**, type locality 240L-6, elevation 1,750-1,900 feet; also locality 240L-2, elevation 1,550 feet, 2 sinistral; 240L-3, elevation 1,550-1,650 feet, 1 dextral,

3 sinistral; 240L-4, elevation 1,750 feet, all Meinecke-collected, 1933 (figs. 5, 5a, p. 105).

The typical color pattern occurs on 40 percent of the shells in area 56. Thirty-three percent have a reddish-brown banded color pattern (pl. 7, fig. 24a), which has the postembryonic whorls white, lined with hay's maroon; impressed sutural band russet. Half of these reddish-brown banded shells are similar to plate 7, figure 23; last postembryonic whorl and a half white, banded just above, at, and below the periphery with hay's maroon; impressed sutural band russet. The light color form occurring on 27 percent of the shells is shown by an elongate shell (pl. 7, fig. 24); the postembryonic whorls white faintly banded with pale olive gray at the edge of the periphery, last half whorl at and below the periphery lined with black. Length 17.7 mm., greater diameter 12.0 mm., spire height 9.2 mm.

ACHATINELLA APEXFULVA EWAENSIS var. 1

PLATE 2, FIGURE 4; PLATE 7, FIGURES 19-20

Area 51: **North-South Waiawa Ridge**, locality 233Ba, elevation 1,150 feet, 1 sinistral; 233B, elevation 1,450 feet, 14 sinistral; 234B, elevation 1,500 feet; 235B, elevation 1,500-1,550 feet, 4 dextral; 236B, elevation 1,500-1,650 feet, 1 sinistral; 237B, elevation 1,700 feet, 3 dextral, 9 sinistral; 238B, elevation 1,700-1,750 feet, 1 dextral; 239B, elevation 1,700-1,750 feet, 1 dextral, 5 sinistral; **North Waiawa North-South Branch Ridge**, locality 230D, elevation 1,650 feet, 13 sinistral; 231D, elevation 1,700-1,750 feet, 1 sinistral; 232D, elevation 1,950-2,000 feet, 3 sinistral, all collected by Meinecke, 1933; **Waiawa-Waiahole Ridge**, Spalding, BBM 117388 (figs. 4, 4a, p. 53).

The color pattern of many of the forms existing in area 51 are not very strikingly different from those of the forms obtainable from area 56. The main difference is that the typical form of the shell from area 56 has the embryonic whorls more intensely banded with yellow than the shells of area 51, and a few color patterns (pl. 7, figs. 19, 19a) are not found in area 56.

The usual form and color pattern (pl. 2, fig. 4) has the first embryonic whorl pale pinkish buff, remaining embryonic whorls upper half white, lower half cream color; first half of first postembryonic whorl white, banded just above the edge of the periphery with a faint band of cream color, remaining postembryonic whorls white with a line of ochraceous buff on the last whorl and a half just above the edge of the periphery, last whorl at and below the periphery

lined and banded with seal brown; lip and columella callus pale brownish vinaceous. Length 18.4 mm., greater diameter 12.2 mm., spire height 9.0 mm.

A dextral shell (pl. 7, fig. 19) has the postembryonic whorls cartridge buff faintly tinted with lines and axial streaks of cream buff, last whorl lined and banded with seal brown; lip and columella callus vinaceous fawn.

An obese sinistral shell (pl. 7, fig. 19a), length 19.3 mm., greater diameter 13.4 mm., spire height 9.1 mm., shows a gray color pattern which is similar to the gray color patterns (pl. 8, figs. 6a, 8) found in areas 55 and 58, but not found in area 56 or other areas containing varieties of *A. a. ewaensis*. The embryonic whorls are white, banded on the lower half with chamois; postembryonic whorls white, banded on the last whorl above and below the periphery with light gull gray, and lined at the periphery on the last whorl and at the base of the last whorl with carob brown.

Four specimens in area 51 have a lined pattern (pl. 7, fig. 20) that is similar to the typical *A. a. ewaensis* color pattern (pl. 2, fig. 15) of area 56; embryonic whorls white, banded on the lower three-fourths of the whorl with warm sepia on the first whorl and shading to ochraceous tawny on the remaining embryonic whorls; postembryonic whorls white, first postembryonic whorl banded on the lower half with warm buff, last whorl and a half lined with seal brown. This shell also shows an elongate form. Length 20.1 mm., greater diameter 12.3 mm., spire height 10.7 mm.

ACHATINELLA APEXFULVA EWAENSIS var. 2

PLATE 2, FIGURE 12; PLATE 7, FIGURES 21-21b

Area 53: **Waiawa-Kipapa Ridge**, locality 244*, elevation 1,500-1,700 feet, Meinecke, 1929 (figs. 5, 5a, p. 105).

The shells in area 53 differ from those of the other areas of varieties of *A. a. ewaensis* by having yellow banded color patterns (pl. 2, fig. 12; pl. 7, fig. 21). The usual form and color pattern of the shell (pl. 2, fig. 12) has the first embryonic whorl white banded on the lower fourth of the whorl with bone brown, remaining embryonic whorls upper half white, lower half cinnamon buff; postembryonic whorls white spirally banded with cinnamon buff; lip and columella callus white faintly tinted with light vinaceous fawn. Length 17.1 mm., greater diameter 11.5 mm., spire height 9.0 mm.

The color of the bands on the postembryonic whorls (pl. 7, fig. 21) may be darker, being sudan brown, and the embryonic whorls may

be larger and less blunt than those of the typical form. Eight percent of the shells are entirely white and are similar to plate 7, figure 21*a*. A dark banded form (pl. 7, fig. 21*b*) occurs on 30 percent of the shells; the postembryonic whorls shade from sudan brown axially streaked with warm buff to carob brown on the last whorl and a half, the edge of the periphery and below the periphery white, base banded and lined with carob brown.

ACHATINELLA APEXFULVA EWAENSIS var. 3

PLATE 2, FIGURE 11; PLATE 7, FIGURES 25, 26

Area 52: **Waiawa-Kipapa Ridge**, locality 243-2, elevation 1,500-1,550 feet, Meinecke, 1933; 243-3-4*, elevation 1,500-1,620 feet, Meinecke, 1929, 5 dextral, 5 sinistral; 243-4*, Welch, 1934 (figs. 5, 5*a*, p. 105).

Area 52 contains forms (pl. 2, fig. 11) similar to typical *A. a. ewaensis*, but differing in having the embryonic whorls not as markedly banded with yellow, and in having the last whorl banded with lighter reddish-brown bands. With the typical pattern are mixed color patterns (pl. 7, figs. 25, 26), which resemble the shells of area 72.

The usual form and color pattern of the shell (pl. 2, fig. 11) has the embryonic whorls bicolored, upper half or three-quarters white, lower half or fourth of the whorl banded with yellow deepening to chamois; postembryonic whorls white, last whorl below the periphery banded with chocolate; lip and columella callus pale grayish vinaceous. Length 18.7 mm., greater diameter 13.0 mm., spire height 9.3 mm., number of whorls $6\frac{1}{4}$.

Out of 16 specimens from locality 243-2, 12 are dextral, 8 of which are similar to plate 2, figure 11. Three of the dextrals are similar to the shell of plate 7, figure 25, which has the postembryonic whorls white spirally lined and banded with olive buff, last whorl at the edge of the periphery banded with white, below the periphery lined with two lines of bone brown and banded with smoke gray, last half whorl lined above the white peripheral band with a line of bone brown and six lines of bone brown below the peripheral band. Length 19.0 mm., greater diameter 12.5 mm., spire height 10.2 mm.

The color pattern on three shells looks like a light form of the shells from area 71 or 72. One of these three shells (pl. 7, fig. 26) has the postembryonic whorls white, spirally lined with deep olive buff; impressed sutural band amber brown, subsutural band ochraceous tawny.

ACHATINELLA APEXFULVA EWAENSIS var. 4

PLATE 2, FIGURE 13; PLATE 7, FIGURES 22, 22a

Area 54: **Waiawa-Kipapa Ridge**, locality 246*, elevation 1,800 feet, Meinecke, 1929; 246a, elevation 2,000-2,100 feet, 2 sinistral, Hosaka, 1935. Meinecke also collected a lot, BBM 118442, from the general region of locality 244 to 244-3?. But since the shells differ from those in locality 244, I shall consider the shells to have come from the region of locality 244-3? Since the lot was collected before 1933, the shells may represent a series collected above area 53 (figs. 5, 5a, p. 105).

The yellow banded color patterns of area 53 do not occur in area 54. The usual color pattern (pl. 2, fig. 13) occurring on 77 percent of the shells in locality 246 has the embryonic whorls white, banded on the lower fourth of the whorl with a band of russet which lightens to chamois on the last half embryonic whorl; postembryonic whorls white, lined and banded on the last whorl with chocolate. Twenty-three percent have a color pattern similar to *A. a. irwini* var. 1 (pl. 8, fig. 15a) only the embryonic whorls are not like *irwini*, being banded with yellow.

The series of shells from locality 244-3? contains a mixture of patterns. A very lined form (pl. 7, fig. 22) has the first embryonic whorl upper half white, lower half verona brown, remaining embryonic whorls honey yellow on the lower three-fourths of the whorl, upper fourth white; first two postembryonic whorls shade from honey yellow to ochraceous tawny lined with white, last whorl banded and lined with carob brown. The last whorl of this shell resembles the lined pattern on the last whorl of *A. a. ewaensis* (pl. 7, fig. 24a).

The postembryonic whorls (pl. 7, fig. 22a) may be white, banded on the first two postembryonic whorls just above the edge of the periphery with buckthorn brown, last whorl banded at the edge of the periphery and below the periphery with liver brown; lip and columella callus vinaceous fawn.

ACHATINELLA APEXFULVA EWAENSIS var. 5

PLATE 2, FIGURE 14; PLATE 8, FIGURES 6-6b

Area 55: **North-Central Kipapa Ridge**, locality 240L-1-1a*, elevation 1,450-1,550 feet, 1932; 240L-1, elevation 1,550 feet, 1933, Meinecke (figs. 5, 5a, p. 105).

This variety of *A. a. ewaensis* is intermediate between *A. a. ewaensis* and a lower gray race which is probably a form closely related to *A. a. virgatifulva*. The color patterns figured from area 55 are quite distinct from those of area 56, but mixed with these are a

few specimens with patterns similar to *A. a. ewaensis* patterns. Very possibly the variety is distinct enough to be considered a subspecies, but I am reluctant to so consider it until more material is available for study.

The usual color pattern (pl. 2, fig. 14) on 51 percent of the shells from locality 240L-1-1a* has the embryonic whorls bicolored, upper third white, lower two-thirds honey yellow; postembryonic whorls white, banded just above the edge of the periphery with honey yellow on the first whorl, on the first half of the penultimate the band is cinnamon buff axially streaked with mikado brown, on the last whorl and a half the band is seal brown, below the periphery the base has a band of seal brown; lip and columella callus light vinaceous fawn. Length 17.2 mm., greater diameter 12.3 mm., spire height 8.5 mm., number of whorls $5\frac{1}{2}$.

Nine percent may be devoid of dark bands (pl. 8, fig. 6a), having the postembryonic whorls white, tinted with pale mouse gray; lip pale vinaceous fawn, number of whorls 6. An obese shell (pl. 8, fig. 6) shows a color pattern on 17 percent; the postembryonic whorls white tinted with gull gray, the base fuscous black axially streaked with pale smoke gray, and pale pinkish buff; lip not developed. Length 17.4 mm., greater diameter 13.5 mm., spire height 9.3 mm. The typical *ewaensis* pattern (pl. 2, fig. 15) is present on 21 percent of the shells.

One specimen is found in both lots of shells from area 55 which may be a stray shell belonging to a distinct lower race. The first embryonic whorl of one of the shells having this peculiar pattern (pl. 8, fig. 6b) is worn, the color fuscous, the next embryonic whorl upper half white, lower half pale smoke gray, last embryonic whorl white; postembryonic whorls white axially streaked with zigzag lines of bone brown, on the last whorl the white peripheral band has a line of bone brown in it at the edge of the periphery, base bone brown axially streaked with white. Length 17.2 mm., greater diameter 11.1 mm., spire height 9.5 mm.

In locality 240L-1, out of 12 live shells approximately 42 percent are similar to plate 8, figure 6a, 33 percent to plate 8, figure 6, 17 percent to plate 2, figure 14, and 8 percent to plate 8, figure 6b.

ACHATINELLA APEXFULVA EWAENSIS var. 6

PLATE 2, FIGURE 18; PLATE 8, FIGURES 7-7b

Achatinella leucorraphe irwini PILSBRY and COOKE, Man. Conch., vol. 22, pp. 304, 305, pl. 59, figs. 12, 15, 15a (only), 1914. These patterns illustrated by Pilsbry occur on the Kipapa-Waikakalaua Ridge either in area 57 or in a region including the lower part of area 57 and the upper part of area 74.

Area 57: Kipapa-Waikakalaua Ridge, locality 252-1-2?, approximate elevation 1,500-1,600 feet, 4 dextral; 253, elevation 1,650 feet, 1 dextral; 254, elevation 1,800-1,850 feet, 7 dextral; 255, elevation 1,800-1,850 feet, 2 dextral, all Meinecke-collected, 1933. In 1932 Meinecke, BBM 121935-121936, collected a series of 49 shells of this variety, which probably came from locality 252-1-2?. Another lot, BBM 121937-121938, collected by Meinecke in 1932 probably comes from locality 253?. Most of the collecting below locality 253? on this ridge is not very reliable and should be carefully checked (figs. 5, 5a, p. 105).

Although the usual form and color pattern of plate 2, figure 18, and the peculiar color patterns (pl. 8, figs. 7, 7a) of area 57, are very distinct, other patterns (pl. 8, fig. 7b) occur which are so similar to some of the color patterns (pl. 8, figs. 1, 2) of area 70 that mixed lots would be hard to separate with 100 percent accuracy. Usually the shells from area 57 are smaller than shells from area 70, and as long as the characteristic patterns of the region are present they are easy enough to separate. The Meinecke lots from 251-1-2? form the largest series available for study from area 57, and the following discussion will be based on it.

The usual form and color pattern of the shell (pl. 2, fig. 18) on 67 percent of the shells has the embryonic whorls white, banded on the lower half of the whorl with cream buff; postembryonic whorls white, last two whorls spirally lined with warm sepia; lip and columella callus light vinaceous fawn; impressed sutural band natal brown lightening to wood brown on the last half whorl. Length 17.1 mm., greater diameter 11.7 mm., spire height 9.2 mm. The spiral lines on the last whorl may be broken and the spire elongate in form (pl. 8, fig. 7); postembryonic whorls white, last whorl lined with snuff brown, the lines broken by axial streaks of white; impressed sutural band snuff brown. Length 17.0 mm., greater diameter 11.5 mm., spire height 9.2 mm. An obese shell (pl. 8, fig. 7a) has the embryonic whorls white with a single peripheral band of saccardo's umber axially streaked with white, last half whorl faintly lined with snuff brown. Length 16.4 mm., greater diameter 12.5 mm., spire height 8.2 mm.

The usual form of a sinistral and an example of the dark lined form of the shell is shown on plate 8, figure 7b, postembryonic whorls white spirally lined on the last whorl and a half with bone brown and natal brown. Length 16.6 mm., greater diameter 11.7 mm., spire height 8.8 mm. This pattern may be darker and resemble plate 8, figure 2, a shell pattern from area 70. Twenty-five percent have a white spire and a basal band similar to typical *A. a. ewaensis* (pl. 2,

fig. 15) of area 56. Two specimens have a pattern resembling plate 8, figure 6, except that the basal gray band is lighter, and two resemble plate 8, figures 7, 7a.

ACHATINELLA APEXFULVA EWAENSIS var. 7

PLATE 2, FIGURE 19; PLATE 8, FIGURES 8-10

Area 58: **Kipapa-Waikakalaua Ridge**, locality 256, elevation 1,750-1,800 feet; 257, elevation 1,800-1,950 feet; 258, elevation 1,900-1,950 feet, 10 dextral, Meinecke, 1933 (figs. 5, 5a, p. 105).

Lined forms similar to those occurring in area 57 (pl. 8, fig. 7b) are rare or absent in area 58. In locality 256 the ground color of the shell is white, tinted with yellow or gray; above this locality the white ground is not tinted with yellow. In the entire area the characteristic color patterns have one dark basal band or line.

The usual color pattern in area 58 (pl. 2, fig. 19) has the embryonic whorls honey yellow, upper half or three-quarters white; post-embryonic whorls white, tinted with pale gull gray above the periphery, at the periphery a band of white, tinted with cartridge buff, below the peripheral band a band of seal brown, base cartridge buff; impressed sutural band the ground color; lip and columella callus pale grayish vinaceous. Length 17.4 mm., greater diameter 12.0 mm., spire height 8.6 mm.

A variation of the typical pattern (pl. 8, fig. 8) is a two-lined pattern; postembryonic whorls above the periphery white, tinted with pale gull gray, last whorl below the periphery ivory yellow tinted with colonial buff, lined at the edge of the periphery and below the periphery by two lines of bone brown. The basal lines may be wider, becoming two basal bands. Another common pattern of this area is the white color form of plate 8, figure 6, tinted with pale gull gray. Usually the shells from area 58 have blunter embryonic whorls than the shells from areas to the south.

In the higher localities of 257 and 258 the same general plan of banding and color pattern occurs. Plate 8, figure 9, shows a dextral with a color pattern similar to that of plate 2, figure 11, except that there are two subperipheral bands instead of five. In locality 258 two very much lined specimens are found. These are the only two shells with a much banded or lined pattern in the entire area. One of these (pl. 8, fig. 10) has the first postembryonic whorl and a half white, banded on the lower half of the whorl with chamois, last whorl and a half white banded and lined with chocolate. This locality should be collected again to ascertain whether these two shells with

the lined pattern really belong to area 58 or whether they are present owing to a mixture. Shells of this pattern are more usual in areas 74 or 57.

ACHATINELLA APEXFULVA EWAENSIS var. 8

PLATE 2, FIGURE 22; PLATE 8, FIGURES 11-12a

Area 59: **Waikakalaua-South Kaukonahua Ridge**, general region of localities 261-262?, approximate elevation 1,450-1,529 feet, 1913; 262*, elevation 1,450-1,500 feet, Meinecke, 15 dextral, 4 sinistral, 1932, BBM 121945-121946. Also collected by Wilder, BBM 50574, probably in the immediate vicinity of area 59 (figs. 5, 5a, p. 105).

In area 59 the shells have the first embryonic whorl and a half banded on the lower half of the whorl with brown similar to those of areas 61? and 62?, and the remaining embryonic whorls are strongly banded with yellow, resembling *A. a. ewaensis* (area 56). Some specimens in area 59 (pl. 8, fig. 12) have embryonic whorls and a color pattern very much like typical *ewaensis* (pl. 2, fig. 15) except that the bands are a lighter shade of reddish brown. The localities on this ridge are not accurately plotted and should be carefully collected again. Very probably area 59 can be divided into two areas, the upper containing shells close to *A. a. ewaensis* (pl. 2, fig. 22), the lower one having a distinct race with color patterns similar to the shells of plate 8, figures 11 and 12a, which resemble *A. a. tubersans* var. 2.

The usual form of the shell (pl. 2, fig. 22) and common color pattern has large, flattened, bicolored embryonic whorls; first embryonic whorl white with the lower third of the whorl wood brown, next whorl upper half white, lower band wood brown, last embryonic whorl white, faintly tinted on the lower third of the first half of the whorl with a cream-buff band; postembryonic whorls white spirally banded just above the periphery on the last two whorls with tawny which shades to light grayish olive on the last half whorl, below the periphery of the last whorl a single band of hay's maroon; lip and columella callus pale grayish vinaceous. Length 18.1 mm., greater diameter 12.8 mm., spire height 8.5 mm., number of whorls 5 $\frac{3}{4}$. The last whorl may have all manner of variations; the subperipheral and supraperipheral bands may be made of two smaller bands or lines, or the band above the periphery may be hay's maroon as well as the lower band.

A gray color pattern (pl. 8, fig. 11) found on one or two specimens in area 59, has the first embryonic whorl white, lower third natal brown, remaining embryonic whorls banded on the lower third with

a band of wood brown shading to chamois; first two postembryonic whorls banded just above the edge of the periphery with a band of cream buff shading to pinkish cinnamon, last whorl above the periphery white, lined and banded with a band of cinnamon buff, which band is axially streaked with pale pinkish buff and mikado brown, last half whorl bone brown axially streaked with pale pinkish buff, below the periphery a band of white; impressed sutural band on the first postembryonic whorl white, on the penultimate pinkish buff shading to mikado brown on the last whorl.

In locality 262* (BBM 121946) collected in 1932 by Meinecke, the shells are 78 percent dextral, and only 17 percent have a gray pattern similar to that of plate 8, figure 11. The common color pattern (pl. 8, fig. 12) has the embryonic whorls bicolored, upper half white, lower half honey yellow; postembryonic whorls white, last whorl banded with army brown, shape ovate. Length 18.6 mm., greater diameter 13.0 mm., spire height 9.0 mm. An elongate shell with dark bands and ochraceous tawny lines (pl. 8, fig. 12a) has a color pattern found on only one specimen; the postembryonic whorls are white, spirally lined or banded above the periphery with ochraceous tawny, last whorl banded at and below the periphery with hay's maroon. Length 19.7 mm., greater diameter 12.6 mm., spire height 10.8 mm.

ACHATINELLA APEXFULVA IRVINI Pilsbry and Cooke

PLATE 2, FIGURE 29; PLATE 8, FIGURES 13-14a

Achatinella leucorraphe irvini PILSBRY and COOKE, Man. Conch., vol. 22, pp. 302, 303, pl. 59, fig. 11a (only), 1914.

The lectotype of *A. a. irvini* selected by Pilsbry and myself is figured in the Manual of Conchology on plate 59, figure 11a, and is reproduced in this paper on plate 8, figure 13. The embryonic whorls of the lectotype are bicolored, first embryonic whorl warm sepia, remaining embryonic whorls upper half or fourth cartridge buff or white, lower portion lightens from warm sepia to cream buff on the last whorl; postembryonic whorls white, lined with one or two faint lines of ochraceous buff, last whorl lined at the edge of the periphery with a line of grayish olive, below the periphery a line of light buff, below which are three lines and two bands of warm blackish brown and a basal band of ochraceous buff, and one of warm blackish brown; impressed sutural band warm sepia, shading to bister on the penultimate and first half of the last whorl, on the last half the impressed sutural band is white, the upper edge lined with a line of sayal brown, the lower edge warm blackish brown; lip pale vinaceous fawn. Length 19.0 mm., greater diameter 12.2 mm., spire height

9.6 mm., number of whorls 6. The color pattern of the lectotype is a characteristic one of the North-South Kaukonahua Ridge.

Distribution, area 61?: **North-South Kaukonahua Ridge**, locality 275?, approximate elevation 1,650-1,810 feet, Meinecke, 1923 (figs. 5, 5a, p. 105). Also collected by Wilder, BBM 50576. Lectotype, ANSP 108778. Type locality, the "upper part of the Kaukinehua [Kaukonahua] ridge" (Pilsbry and Cooke, 1914), collected by I. Spalding.

In the Wilder collection there is a series of 22 shells, all sinistral, which probably come from the region of the type locality or the locality of the lectotype. Wilder collected with Spalding, and it is probable that the Wilder lot is from the same place. The shells in the Wilder lot have a uniform color pattern which may mean either that Wilder selected out his color patterns, or that the lot is from a localized area of fairly limited extent. I am inclined to believe it is from a small area because the shells are very similar to those obtained by Meinecke on this ridge in area 61?.

The usual form of the shell in the Wilder lot, BBM 50576 (pl. 2, fig. 29), and the color pattern on 59 percent of the shells has the embryonic whorls bicolored, first whorl cinnamon drab, next whorl upper half white, lower half cinnamon drab, last embryonic whorl white; postembryonic whorls white, lined just above or at the edge of the periphery with sayal brown, last whorl and a half spirally lined with sayal brown and cinnamon buff; lip and columella callus pale vinaceous fawn. Length 18.5 mm., greater diameter 12.3 mm., spire height 9.7 mm.

A variation of the typical pattern (pl. 8, fig. 14) found on three shells is a light pattern; postembryonic whorls white, last whorl at the edge of the periphery faintly banded with pale pinkish buff and cinnamon buff. Another characteristic color pattern (pl. 8, fig. 14a) occurring on 27 percent has the postembryonic whorls white, last whorls faintly spirally lined and banded with pale pinkish buff, last whorl lined at the edge of the periphery and banded and lined below the periphery with hay's maroon; impressed sutural band, on the first postembryonic whorl and a half russet, on the last whorl and a half light buff with a line of russet on the lower half of the band.

ACHATINELLA APEXFULVA IRWINI var. 1

PLATE 2, FIGURE 30; PLATE 8, FIGURES 15-15b

Achatinella leucorraphe irwini PILSBRY and COOKE, Man. Conch., vol. 22, pp. 302, 303, pl. 59, figs. 10, 11, 11b (only), 1914.

Area 62?: **North-South Kaukonahua Ridge**, locality 277?, elevation 1,750-1,900 feet, Meinecke, BBM 122671, 1923, BBM 121973-121974, 1918 (figs. 5, 5a, p. 105).

The usual form of the shell and the form and color pattern of the embryonic whorls are close to *A. a. irwini*. The usual color pattern of the postembryonic whorls is almost identical with the color pattern of the holotype of *A. a. ewaensis*. The two forms of *A. a. ewaensis* are separable because this form does not have a yellow band on the embryonic whorls and has a different range of color patterns.

The usual form (pl. 2, fig. 30) and color pattern on 50 percent of the sinistral shells has the embryonic whorls bicolored, first two embryonic whorls white, banded on the lower third of the whorl with fuscous; postembryonic whorls white faintly tinted with pale gull gray, last whorl banded and lined with seal brown; lip and columella callus pale grayish vinaceous. Length 18.5 mm., greater diameter 12.6 mm., spire height 9.0 mm. A variation of the usual form is a broad banded color pattern (pl. 8, fig. 15) with the same color as plate 2, figure 30. Eighteen percent of the sinistrals have a white color pattern tinted with gray similar to plate 8, figure 6a. Twelve percent may have olive buff or yellow lines similar to *A. a. irwini* mixed with the usual pattern.

The usual form of a dextral (pl. 8, fig. 15a) and color pattern on 50 percent of the dextral shells has the postembryonic whorls white, last whorl faintly lined at the edge of the periphery with pale gull gray, base lined with seal brown. Length 18.2 mm., greater diameter 12.5 mm., spire height 9.3 mm. Twenty-two percent have the banded pattern of plate 8, figure 15, 11 percent have a white pattern similar to plate 8, figure 6a. Seventeen percent have an unusual dark banded pattern (pl. 8, fig. 15b); last two postembryonic whorls dark livid brown banded with pale vinaceous fawn, the bands lined with wood brown or vinaceous buff.

The dextrals do not contain any forms with olive buff or yellow in them similar to *A. a. irwini*. For this reason I believe the dextrals probably came from a higher locality than the sinistrals and probably occur as a pure race of dextrals. The sinistrals may also occur as a pure white banded race without any olive buff or yellow lines on the shell. This section of the North-South Kaukonahua Ridge is not well known and should be carefully collected again.

GROUP OF *A. a. CONIFORMIS* GULICK

ACHATINELLA APEXFULVA CONIFORMIS Gulick

PLATE 2, FIGURE 34; PLATE 9, FIGURES 18-20a

Apex coniformis GULICK, Proc. Zool. Soc. London, 1873, p. 80, pl. 9, fig. 17.
Achatinella sciffitii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 308, 309, 312, pl. 58, figs. 2, 2a, 7; pl. 59, figs. 1a, 1b, 2(?) ; pl. 60, fig. 10a (only), 1914.

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, *Man. Conch.*, vol. 22, pp. 325-326, 327, pl. 60, figs. 5(?), 10a, 1914.

The holotype of *A. a. coniformis* (pl. 9, fig. 18) has the first embryonic whorl and a half white, remaining embryonic whorls light buff; postembryonic whorls pinkish buff axially streaked with avellaneous, last whorl also spirally lined with avellaneous, last 6.4 mm. of the last whorl mikado brown; impressed sutural band russet; lip and columella callus pale cinnamon pink. Length 17.5 mm., greater diameter 12.7 mm., spire height 8.7 mm., number of whorls 6½.

Distribution, area?: Type locality **Ahonui**, Gulick. Holotype, MCZ 39911. Also Kalaikoa, Wahiawa, Helemano, Gulick. These last three localities are undoubtedly an error because all subspecies of *A. apexfulva* found today at a low elevation in the region between South Kaukonahua Stream and Helemano Stream are highly localized. The area occupied by a single race usually covers less than a mile in extent along the top of a ridge or bottom of a gulch, and never extends over two main ridges. Gulick and Smith named a series of species such as *coniformis*, *flavida*, *versicolor*, *gulickii*, and *lilacea* which are undoubtedly distinct subspecies from highly localized localities. However, in the Gulick collection specimens of these very distinct forms are reported from a number of widely separated localities. This indicates that the Gulick collection is a mixture of shells from various localities. This may be accounted for by the fact that most of Gulick's material was obtained from natives.

The typical color pattern of *A. a. coniformis* is exceedingly rare in the Gulick collection in the Bishop Museum, only four juvenile specimens being found. The lots from Ahonui containing these specimens also include a diversity of patterns that belong to other subspecies such as *A. a. gulickii* and *A. a. lilacea*.

An elongate form of the shell with a light shade of the typical color pattern (pl. 9, fig. 19) has the embryonic whorls pale pinkish buff; postembryonic whorls a yellowish hue of avellaneous, spirally lined above the periphery with tilleul buff and fawn color; impressed sutural band mikado brown. A darker shell of the typical color pattern (pl. 9, fig. 19a), also a juvenile, has the embryonic whorls light buff darkening to pinkish buff; postembryonic whorls avellaneous spirally lined and axially streaked with cameo brown, last whorl finely axially streaked with verona brown and spirally lined with light pinkish cinnamon. A specimen that looks like a brown form of *A. a. gulickii* has the first postembryonic and penultimate whorls, above the wood brown supraperipheral band, light drab spirally lined and finely axially streaked with white, last whorl wood brown spirally

lined with white or tilleul buff and axially streaked with benzo brown, peripheral band white; lip and columella callus light pinkish cinnamon.

Mixed with other lots of shells of various subspecies from Ahonui, Kalaikoa, and Wahiawa, a group of distinct color patterns occur which resemble *A. a. coniformis*. All shells similar to *coniformis* are markedly ornamented with fine spiral lines and weakly streaked with fine axial streaks. These forms (pl. 2, fig. 34; pl. 9, figs. 20, 20a) probably came from a single locality or from the same general area as the holotype of *A. a. coniformis*. The holotype is probably a rare color pattern of the subspecies.

In the usual form and color pattern (pl. 2, fig. 34) of *A. a. coniformis* the embryonic whorls shade from white to light buff; first three-fourths postembryonic whorl white axially streaked with brownish drab, next whorl and a fourth dark gray axially streaked and faintly spirally lined with white, last whorl light drab, shading to snuff brown on the last fourth whorl, axially streaked and spirally lined with white; impressed sutural band on the first postembryonic whorl the same as on the rest of the whorl, on the remaining whorls white; lip not completely thickened, color avellaneous; columella callus white tinted with pale vinaceous fawn. Length 17.8 mm., greater diameter 12.5 mm., spire height 9.8 mm., number of whorls $6\frac{3}{4}$.

The color pattern may be more brownish (pl. 9, fig. 20) and the form more elongate than the usual form; embryonic whorls white; first postembryonic whorls, up to the last whorl, tilleul buff axially streaked with pallid mouse gray, last whorl a yellowish hue of vinaceous buff spirally lined with white; impressed sutural band same as rest of whorl; lip light vinaceous fawn. Length 18.3 mm., greater diameter 11.7 mm., spire height 9.4 mm. An obese and strongly lineate form (pl. 9, fig. 20a) has the first two embryonic whorls white, last embryonic whorl cream color; first postembryonic whorl vinaceous drab, lined with white, penultimate whorl light drab spirally lined and axially streaked with white, last whorl drab spirally banded above the periphery with a band of white which is lined with four lines of drab, below the periphery ground lined and streaked with white; lip and columella callus light vinaceous fawn. Length 17.4 mm., greater diameter 13.2 mm., spire height 9.4 mm.

ACHATINELLA APEXFULVA APEXALBA, new subspecies

PLATE 2, FIGURE 35; PLATE 9, FIGURES 26-26d

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 308, 309, 312, pl. 58, figs. 1, 2b, 2c, 16; pl. 59, fig. 1 (only), 1914.

The shell is usually sinistral and resembles the form of *A. a. versicolor*, but differs from *A. a. versicolor* by lacking a white periph-

eral band and having a different range of color patterns. The shell has characteristic white embryonic whorls and contrasting dark brown postembryonic whorls. This subspecies is usually found mixed with *A. a. coniformis* in the Gulick lots although some lots of *apexalba* contain no forms of *A. a. coniformis*. I have separated *apexalba* from *coniformis* because of the fact that *apexalba* has a crisscross color pattern in which the spiral bands are broken or flecked by dark and light axial streaks somewhat resembling *A. a. versicolor*. The shell of *apexalba* has a rough, coarse, or broken pattern, whereas *coniformis* has a solid, finely axially streaked even color. A few specimens are found which might be put in either subspecies. These are probably intermediate forms between the two races.

The embryonic whorls of the holotype (pl. 2, fig. 35) are pale pinkish buff; first two postembryonic whorls light drab axially streaked with hair brown and benzo brown spirally lined with a central line of white, on the penultimate whorl a white subsutural band broken by dark axial streaks, last whorl above and just below the periphery spirally banded with light drab and drab axially streaked with snuff brown, flecked and spirally lined with white, last half whorl darkens to snuff brown, base snuff brown spirally banded with avellaneous and tilleul buff; impressed sutural band chestnut on the first two postembryonic whorls, on the last whorl impressed sutural band the ground color except the upper edge, which is fawn color; lip and columella callus pale vinaceous fawn. Length 18.5 mm., greater diameter 11.7 mm., spire height 10.0 mm., number of whorls 6 $\frac{1}{4}$.

Distribution, area?: Type locality **Wahiawa**, Gulick. Also Kalai-koa, Ahonui, Gulick. The last two localities are probably wrong, if Wahiawa is correct.

The darkest color pattern and elongate form of the shell (pl. 9, fig. 26) measures: Length 17.9 mm., greater diameter 11.3 mm., spire height 10.8 mm.; first two postembryonic whorls drab spirally banded with fawn color and axially streaked with verona brown, last whorl saccardo's umber, banded with fawn color above the periphery, below the periphery a band of white and lines of white; impressed sutural band russet lightening in color at the extreme upper edge to tawny.

A light color pattern (pl. 9, fig. 26a) has the first postembryonic whorl benzo brown with a central white line, penultimate whorl white axially streaked with hair brown and spirally lined with a central band of white, last whorl tilleul buff, spirally lined with verona brown and axially streaked with drab, base banded with a hue between benzo

brown and hair brown; impressed sutural band warm sepia lightening to sayal brown on the last half whorl, subsutural band shades from benzo brown to hair brown and verona brown on the last half whorl.

An extreme obese specimen (pl. 9, fig. 26*b*) has the embryonic whorls white; postembryonic whorls drab axially streaked with hair brown, and on the last whorl also streaked with tilleul buff, on the last two whorls just above the edge of the periphery two lines of white broken by the axial ornamentation, base weakly lined with white; impressed sutural band russet lightening to tawny on the last half whorl. Length 17.6 mm., greater diameter 13.0 mm., spire height 9.2 mm.

A lighter gray color pattern (pl. 9, fig. 26*d*) is strongly axially streaked on the last two postembryonic whorls; penultimate whorl benzo brown, lined with pinkish buff and white and streaked with pale smoke gray, last whorl pale smoke gray lightening to pale cinnamon pink, axially streaked with light drab, spirally banded with drab below the sutural band, and lined with white above and below the periphery. The color may be a very light brownish hue (pl. 9, fig. 26*c*), penultimate whorl similar to that of figure 26*d*, last whorl avellaneous lined with white.

ACHATINELLA APEXFULVA VERSICOLOR Gulick

PLATE 2, FIGURE 33; PLATE 9, FIGURES 21-23

Apex versicolor GULICK, Proc. Zool. Soc. London, 1873, p. 80, pl. 9, fig. 18.
Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 310, pl. 58, figs. 14-14*d*, 15 (only), 1914.

The holotype (pl. 9, fig. 21) has the first embryonic whorl and a half cartridge buff, remaining embryonic whorls cream buff, lined with white; first quarter postembryonic whorl upper half pale gull gray, lower half banded and lined with chamois, remaining postembryonic whorls pale gull gray axially streaked with mouse gray on the penultimate, just above the edge of the periphery a band of bone brown or clove brown up to the last whorl, last whorl pale mouse gray axially streaked with benzo brown, banded above the pale mouse gray peripheral band, and all below, with hay's brown, streaked with pale mouse gray; impressed sutural band the ground color; lip and columella callus pale vinaceous fawn. Length 18.8 mm., greater diameter 13.0 mm., spire height 9.5 mm., number of whorls 6.

Distribution, area?: Type locality, **Ahonui**, Gulick. Also Kalaikoa, Gulick. This race probably occurred somewhere in the region of the North or South Kaula Stream.

The usual form of *A. a. versicolor* (pl. 2, fig. 33) measures: Length 17.2 mm., greater diameter 11.6 mm., spire height 9.2 mm., number of whorls 6; embryonic whorls light buff, lined or banded on the last whorl with white; first half postembryonic whorl pale gull gray, spirally lined with benzo brown below the impressed sutural band of benzo brown, just above the edge of the periphery a line of sayal brown, last half of whorl pale gull gray with an axial streak of snuff brown, first half of the penultimate pale gull gray axially streaked with cinnamon buff, last whorl and a half white or faintly shaded with pallid mouse gray, axially streaked with snuff brown and the ground color, spirally banded or lined with snuff brown and bister, below the edge of the periphery a band of white, base bister axially streaked with white.

A light color pattern (pl. 9, fig. 23) has the postembryonic whorls white or faintly shaded with pallid mouse gray, first postembryonic whorl and a half has a subsutural line of mouse gray, last postembryonic whorl and a half spirally lined and axially streaked with mikado brown and sayal brown, subperipheral band white, base banded with warm sepia and a line of white. A rare pattern (pl. 9, fig. 22) has the last postembryonic whorl above the periphery white shaded with pale gull gray, with a patch or streak of snuff brown above the aperture and on the last half of the whorl, the band at the edge of the periphery, and all below the white subperipheral band, drab axially streaked with benzo brown.

ACHATINELLA APEXFULVA VERSICOLOR var. 1

PLATE 9, FIGURES 24-25b

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 314, pl. 58, figs. 3, 3a, 11; pl. 59, fig. 2, 1914.

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 325, pl. 60, fig. 5a (only), 1914.

Area 78?: Somewhere at a low elevation below area 79 probably in area 78? (figs. 5, 5a, p. 105), on the **North-South Kaukonahua Ridge**, Thurston, BBM 130693-130694, Judd, BBM 110053-110054. Also collected by Gulick and mixed with subspecies of *A. apexfulva* from Kalaikoa and Ahonui.

A. a. versicolor var. 1 is a race of bluish-gray shells with certain color patterns that resemble those of *A. a. versicolor*, but most of its patterns are quite distinct.

A characteristic color pattern (pl. 9, fig. 25) has the postembryonic whorls white, banded just above the periphery and on the last whorl

above and below the periphery with light mouse gray lined with white; impressed sutural band mouse gray with a line of verona brown along the upper edge; lip and columella callus pale vinaceous fawn. Length 19.0 mm., greater diameter 11.7 mm., spire height 10.0 mm.

A dark color pattern and an elongate shell (pl. 9, fig. 25a) measures: Length 19.4 mm., greater diameter 12.1 mm., spire height 11.0 mm. The postembryonic whorls are hair brown axially streaked with benzo brown, and spirally lined with pale pinkish cinnamon or white faintly shaded with pallid mouse gray; on the last half whorl the light lines or bands are pallid mouse gray.

A sinistral shell (pl. 9, fig. 25b) resembles *A. a. versicolor* (pl. 9, fig. 22). The postembryonic whorls below the white subsutural band are benzo brown axially streaked with light drab, last whorl just above and all below the periphery wood brown axially streaked and spirally lined with tilleul buff. The shell may have a lined pattern (pl. 9, fig. 24); embryonic whorls naples yellow, lined with white on the last half whorl; postembryonic whorls lined with natal brown; lip and columella callus white, with the outer edge light vinaceous fawn. The lightest color pattern and an obese dextral (pl. 9, fig. 24a) measures: Length 18.0 mm., greater diameter 13.2 mm., spire height 9.6 mm. Postembryonic whorls white, banded at the suture and just above the edge of the periphery with light drab, base drab gray, lined with white.

ACHATINELLA APEXFULVA WAHIAWA, new subspecies

PLATE 2, FIGURE 36; PLATE 11, FIGURES 1-1b

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 312, 313, pl. 58, fig. 8; pl. 59, fig. 2a (only), 1914.

Gulick called this race of shells *A. pica*. Pilsbry and Cooke correctly consider the name *pica* a synonym of *A. a. apexfulva*. The form is a distinct lowland one which probably occurred at some low elevation below areas 90 and 91?? (fig. 5a, p. 105). *A. a. wahiawa* resembles *A. a. coniformis* but differs in usually being more strongly axially streaked, lacking pronounced fine spiral lines, and having white embryonic whorls. The shell is usually dextral.

The holotype (pl. 2, fig. 36) has white embryonic whorls darkening to pale pinkish buff on the last embryonic whorl; the first two and three-fourths postembryonic whorls vinaceous buff axially streaked with rood's brown, last whorl avellaneous axially streaked and spirally banded and lined with benzo brown and cameo brown; impressed sutural band mikado brown darkening on the last half whorl to walnut

brown; lip and columella callus white with a faint tint of seashell pink. Length 17.8 mm., greater diameter 12.5 mm., spire height 9.6 mm., number of whorls $6\frac{1}{4}$.

Distribution, area? **Wahiawa**, Gulick.

The spire may be more concave (pl. 11, fig. 1a), the embryonic whorls more pointed, and the last whorl flattened and less rounded at the edge of the periphery than the holotype; the color pattern is similar to that of the holotype. A narrow specimen (pl. 11, fig. 1) and light color pattern measures: Length 17.1 mm., greater diameter 12.0 mm., spire height 9.4 mm.; first half postembryonic whorl pale pinkish buff axially streaked with warm buff, next whorl and a half pale vinaceous fawn axially streaked with light drab, last whorl seashell pink, axially streaked with vinaceous fawn and fawn color, at the edge of the periphery and about the base a line of benzo brown, in the umbilical region a patch of chamois.

A dark color pattern (pl. 6, fig. 1b) is figured, showing the dorsal side of the shell, to exhibit the contrast between the white embryonic whorls and the postembryonic whorls; the last half of the first postembryonic whorl and the penultimate whorl light cinnamon drab, finely axially streaked with dark vinaceous brown, first half of last whorl drab axially streaked with dark vinaceous brown, last half whorl almost solid dark vinaceous brown streaked with drab; impressed sutural band walnut brown. Length 16.5 mm., greater diameter 12.6 mm., spire height 9.1 mm.

GROUP OF *A. a. LILACEA* GULICK

ACHATINELLA APEXFULVA GULICKII Smith

PLATE 10, FIGURES 14-15b

Apex gulickii SMITH, Proc. Zool. Soc. London, 1873, p. 78, pl. 9, fig. 19 (not fig. 17).

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 325, 326, 327, pl. 58, fig. 10a (?); pl. 60, figs. 6, 6a, 12 (only), 1914.

A. a. gulickii is characterized by having a white or light peripheral band and a grayish or gray-brown color pattern. The holotype (pl. 10, fig. 14) has the embryonic whorls cartridge buff; first half postembryonic whorl cinnamon buff darkening to cameo brown on the last half of the whorl, penultimate whorl drab gray axially streaked with benzo brown, last whorl pinkish buff above the peripheral band of gull gray axially streaked with benzo brown and light drab, below the periphery a band of benzo brown, below which is a band of pale

gull gray spirally lined with benzo brown, about the umbilicus a faint band of cartridge buff; impressed sutural band on the first half postembryonic whorl same as the ground color, on the remaining whorls pecan brown lightening to cinnamon on the last whorl; lip and columella callus light vinaceous cinnamon. Length 18.2 mm., greater diameter 12.3 mm., spire height 8.8 mm., number of whorls 6.

Distribution, area?: Type locality **Kalaikoa**, Gulick. Also reported from **Ahonui**, Gulick. The type locality was probably a restricted locality somewhere between North and South Kaukonahua Streams.

The color pattern of the holotype is an unusually dark gray pattern. A more usual one in the Gulick lots (pl. 10, fig. 15) has cream-buff embryonic whorls darkening to chamois on the last half embryonic whorl; postembryonic whorls pale vinaceous fawn axially streaked with vinaceous drab and pale brownish drab, peripheral band and base white, subperipheral band light brownish drab; impressed sutural band pinkish cinnamon lightening on the following whorls to pale ochraceous buff.

The darkest color pattern (pl. 10, fig. 15a) has the first two embryonic whorls cartridge buff darkening to chamois on the last embryonic whorl; postembryonic whorls pale quaker drab axially streaked with anthracene purple, on the last whorl about the periphery a line of white, last fourth whorl pinkish buff axially streaked with cinnamon drab, lip not formed. Another shell has a yellowish pink hue (pl. 10, fig. 15b); postembryonic whorls up to the last whorl vinaceous drab axially streaked with light pinkish cinnamon, last whorl light pinkish cinnamon streaked with vinaceous drab, peripheral band white; impressed sutural band vinaceous cinnamon.

ACHATINELLA APEXFULVA GULICKII var. 1

PLATE 10, FIGURE 16, 16a

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 325, 326, pl. 60, figs. 11, 13 (only), 1914.

Area?: **Ahonui**, Gulick.

This light pinkish variety looks like an intermediate race between *A. a. gulickii* and *A. a. lilacea*, and is considered a variety of *A. a. gulickii* because of the light band just below or at the edge of the periphery of the last whorl.

The usual form and color pattern (pl. 10, fig. 16) has the embryonic whorls cartridge buff; first postembryonic whorl and a half vinaceous fawn axially streaked with pale brownish drab, last whorl and a half pale ecru drab axially streaked with white and faintly banded above

the periphery with pale vinaceous fawn, on the last whorl a peripheral band of white, base white, subperipheral band pale ecru drab; impressed sutural band pale vinaceous fawn; lip and columella callus white faintly tinted with pale vinaceous fawn. Length 19.0 mm., greater diameter 12.8 mm., spire height 10.4 mm., number of whorls $6\frac{1}{2}$.

The color may be light pink (pl. 10, fig. 16a) and the color pattern may resemble that of *A. a. lilacea* (pl. 10, fig. 10), although differing in having the last whorl, just below the periphery and at the base, banded and lined with white.

ACHATINELLA APEXFULVA GULICKII var. 2

PLATE 10, FIGURES 21-21b

Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 309, 312, 315, pl. 58, figs. 13-13b; pl. 59, fig. 4e (only), 1914.

Area?: Kalaikoa, Gulick.

The form was described by Smith as a variety of *A. a. gulickii*. It is probably an intermediate race between *A. a. gulickii* var. 1 and *A. a. flavida*. The postembryonic whorls are of a pinkish color above the periphery, last whorl at and below the periphery banded with yellow.

The usual color pattern (pl. 10, fig. 21) on 37 percent of the shells has the embryonic whorls white, shading to cream buff on the last half embryonic whorl; first half postembryonic whorl vinaceous fawn with a central line of pale pinkish cinnamon, the remaining postembryonic whorls vinaceous pink, lined and axially streaked with pale pinkish cinnamon, the last whorl is tinted with chamois, a band of fawn color below the pale pinkish cinnamon band just below the edge of the periphery, base cream buff tinged with chamois; impressed sutural band pale pinkish cinnamon; lip and columella callus a very dilute tint of a pink or tilleul buff.

Thirty-three percent have a lighter or yellow color pattern (pl. 10, fig. 21a); the first postembryonic whorl and a half pale drab gray axially streaked with light cinnamon drab, first half of last whorl above the periphery pale drab gray tinged with chamois, last half almost entirely chamois, base chamois below the peripheral band of chamois, subperipheral band a faint shade of drab gray covered over by the ground color; impressed sutural band pale pinkish cinnamon.

A sinistral specimen (pl. 10, fig. 21b) shows the dark form of 30 percent of the shells; postembryonic whorls above the periphery fawn color; impressed sutural band fawn color; subsutural band or

line on the last two whorls white, shading to chamois on the last half whorl; the last half whorl is tinted with chamois, last whorl below the narrow peripheral band of white is chamois with a central band of fawn color.

ACHATINELLA APEXFULVA FLAVIDA Gulick

PLATE 10, FIGURES 17-20

Apex flavidus GULICK, Proc. Zool. Soc. London, 1873, p. 80, pl. 10, figs. 1, 1a.
Achatinella swiftii NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 306, 311, 312, 315, pl. 58, figs. 10, 12-12b (only), 1914.

The subspecies is characterized by having a light yellow color pattern. The form of the shell resembles *A. a. gulickii* var. 2. The holotype is a rare color pattern and not characteristic of the subspecies. The holotype of *A. a. flavida* (pl. 10, fig. 17) has the first embryonic whorls a very dilute shade of pale ecru drab, fading to white; postembryonic whorls white, first postembryonic whorl with a cinnamon-buff supraperipheral line which widens on the last two whorls to a band of mikado brown or walnut brown; the impressed sutural band white on the first embryonic whorl, on the last two whorls mikado brown darkening to cacao brown, base cartridge buff; columella callus pale pinkish cinnamon; lip cartridge buff. Length 19.8 mm., greater diameter 12.8 mm., spire height 10.7 mm., number of whorls $6\frac{1}{2}$.

Distribution, area?: Type locality **Kalaikoa**, Gulick (probably somewhere in South Kaukonahua Stream at a low elevation). Also Ahonui, Gulick, which is probably erroneous if Kalaikoa is correct, because the type locality was probably of limited extent.

Gulick's var. a (pl. 10, fig. 18) has a more usual color pattern; first embryonic whorl and a half white, shading to cream buff on the later embryonic whorls; first two postembryonic whorls pinkish buff axially streaked with cinnamon buff and mikado brown; below the impressed sutural band of tawny, which darkens on the last two whorls and a half to orange cinnamon, there is a band of white; on the penultimate whorl there is another band of white just above the edge of the periphery, last whorl chamois spirally banded with sayal brown. Length 17.6 mm., greater diameter 12.2 mm., spire height 9.3 mm., number of whorls 6. This color pattern occurs on 34 percent of the combined Kalaikoa and Ahonui lots, all but 7 of which are from Kalaikoa.

The usual color pattern in the Bishop Museum lots of the Gulick collection (pl. 10, fig. 19) has the embryonic whorls white, post-

embryonic whorls white up to the last whorl, last whorl above the periphery cream buff, with a band made up of fine drab-gray lines which darken on the last half whorl to cinnamon drab, above the band a line of avellaneous, below and at the edge of the periphery chamois, banded about the center of the base with two bands or lines of natal brown; impressed sutural band russet; lip and columella callus a very dilute shade of vinaceous fawn.

The shell may not be strongly ornamented with gray or brown lines or bands (pl. 10, fig. 19a), the first postembryonic whorl white spirally lined with warm sepia, penultimate whorl white, last whorl mustard yellow faintly banded with bands slightly darker than the ground; impressed sutural band on the first two postembryonic whorls russet, on the first half of the last whorl white with upper edge russet, on the last half whorl white. This color pattern occurs on 23 percent of the shells.

A variation of the usual color pattern (pl. 10, fig. 19b) has the first postembryonic whorl and half army brown with a subsutural line of white, and another line of white just above the periphery which broadens on the last half of the penultimate to a band, so that the whorl is white with a median band of army brown on the last half of the penultimate, last whorl, above the white peripheral band or line, banded with a white subsutural band, a band of army brown, and a band of chamois, on the last half whorl subsutural band tinted with chamois, below the periphery the ground chamois, with a central line of army brown.

In other lots of shells from Ahonui and Kalaikoa sometimes marked by Gulick "*tuberans-tumefacta*," is a white shell (pl. 10, fig. 20) which is banded on the postembryonic and on the impressed sutural band with pecan brown. I believe that this rare color pattern is a light color pattern of *flavida* which lacks the usual yellow color. Pilsbry and Cooke (pl. 58, fig. 10) figured a sinistral shell with this color pattern.

ACHATINELLA APEXFULVA LILACEA Gulick

PLATE 3, FIGURE 2; PLATE 10, FIGURES 8-11

Apex lilaceus GULICK, Proc. Zool. Soc. London, 1873, p. 79, pl. 10, fig. 4.

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 325, 328, pl. 60, figs. 14, 14a (only), 1914.

The holotype of *A. a. lilacea* (pl. 10, fig. 8) has the embryonic whorls white; postembryonic whorls white axially streaked with light vinaceous fawn darkening to vinaceous fawn on the last whorl;

impressed sutural band white; lip and columella callus light vinaceous fawn. Length 20.2 mm., greater diameter 13.2 mm., spire height 10.7 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 83b??: Type locality **Kalaikoa**, Gulick; also **Ahonui**, Gulick. The type locality containing a pure race of pink shells of the typical *A. a. lilacea* pattern has not been located in recent years. Meinecke in locality 280* (fig. 5, p. 105), **North Kaukonahua-Poamoho Ridge**, BBM 121982, found two specimens of typical *A. a. lilacea* mixed with *A. a. lilacea* var. 1. This indicates that Gulick's type locality was probably somewhere in the region of North Kaukonahua Stream which was all or part of Gulick's Ahonui, and not in Kalaikoa. The possible region of the type locality area 83b?? has been plotted on figure 7, (p. 194).

The usual form of *A. a. lilacea* (pl. 3, fig. 2) has the embryonic whorls pale pinkish buff; postembryonic whorls seashell pink axially streaked with buff pink; impressed sutural band white; lip and columella callus shell pink. Length 18.7 mm., greater diameter 12.2 mm., spire height 10.0 mm., number of whorls 6. A narrow specimen (pl. 10, fig. 9) measures: Length 18.0 mm., greater diameter 11.8 mm., spire height 11.0 mm. An obese specimen (pl. 10, fig. 10) measures: Length 18.2 mm., greater diameter 12.8 mm., spire height 10.0 mm. The color pattern of figures 9 and 10 is similar to that of plate 3, figure 2, except that the impressed sutural band is the same as the rest of the whorl.

One of the Meinecke pink shells (pl. 10, fig. 11) from locality 280* has the embryonic whorls white; postembryonic whorls pale salmon color; impressed sutural band the same as the rest of the whorl.

ACHATINELLA APEXFULVA LILACEA var. 1

PLATE 3, FIGURE 3; PLATE 10, FIGURES 12-13

Area 83: **North Kaukonahua-Poamoho Ridge**, locality 280-1-280*, approximate elevation 1,450 feet, Russ, 1929-1933; 280*, elevation 1,350-1,450 feet, Meinecke, 1932. Also collected by Wilder, BBM 50585.

Area 83a: **North Kaukonahua-Poamoho Ridge**, locality 281-2*, elevation 1,500 feet, 1932, BBM 121987, 121988; 281-1, elevation 1,500-1,550 feet, Meinecke, 5 dextral 1933 (figs. 5, 5a, p. 105). Locality 281-2*, plotted from memory, probably should be below locality 281-1.

The shell is very similar in form and color pattern to typical *A. a. lilacea*, differing in having a bluish-gray hue instead of a pinkish color pattern. This race is probably intermediate between *A. a. lilacea* and *A. a. lilacea* var. 2.

The usual color pattern and form of the shell (pl. 10, fig. 12) has the embryonic whorls white; postembryonic whorls pale vinaceous fawn axially streaked with light vinaceous fawn on the first postembryonic whorl and light cinnamon drab on the penultimate, last whorl ecru drab axially streaked with cinnamon drab and benzo brown and faintly spirally lined and axially streaked with tilleul buff; impressed sutural band same as the rest of the whorl, upper edge white; lip and columella callus pale grayish vinaceous. Length 19.0 mm., greater diameter 12.0 mm., spire height 10.9 mm.

An obese shell (pl. 10, fig. 12a) measures: Length 17.8 mm., greater diameter 12.7 mm., spire height 9.1 mm.; shows a very light color form; first half postembryonic whorl pale pinkish buff, next whorl and a quarter up to the last whorl light vinaceous fawn axially streaked with a dilute shade of vinaceous fawn, last whorl pale ecru drab axially streaked with cinnamon drab and tilleul buff on the last whorl; impressed sutural band white. White sutural bands occur on one or two specimens in each lot.

In the Russ lot from locality 280-1-280*, 66 percent are pinkish forms (pl. 10, fig. 12) and 36 percent bluish-gray forms (pl. 10, fig. 12b; pl. 3, fig. 3). In the Meinecke lot from 280*, 56 percent are pinkish forms and 44 percent bluish pink. Locality 281-2*, has 71 percent bluish forms, and 281-1 contains no pink forms. These last two localities have been separated out into area 83a to emphasize the trend toward bluish-gray color forms above area 83. More collecting should be done in this region to determine whether bluish-gray shells exist in a pure locality below area 84 where the streaked color pattern changes but the color is definitely bluish gray.

The usual color pattern and form of a bluish-gray shell (pl. 3, fig. 3) has the embryonic whorls pale pinkish buff; first postembryonic whorl pale pinkish buff, last two whorls pale mouse gray axially streaked with quaker drab, sorghum brown, and tilleul buff, last fourth whorl tilleul buff axially streaked with avellaneous; impressed sutural band tilleul buff axially streaked with vinaceous buff; lip and columella callus light vinaceous fawn. Length 19.0 mm., greater diameter 12.0 mm., spire height 10.5 mm. The color of the sutural band is unusual.

The color pattern may be lighter, the form elongate and the impressed sutural band white (pl. 10, fig. 12b), which is usual; embryonic whorls white; first half postembryonic whorl white, last half white axially streaked with light vinaceous fawn, penultimate and last whorl pale drab gray axially streaked with pale brownish drab and light brownish drab; lip and columella callus light vinaceous fawn.

Length 19.0 mm., greater diameter 12.0 mm., spire height 10.8 mm. Plate 10, figure 13, shows a sinistral shell from area 83a which has the same color pattern as plate 10, figure 12b.

ACHATINELLA APEXFULVA LILACEA var. 2

PLATE 3, FIGURE 4

Area 84: **North Kaukonahua-Poamoho Ridge**, locality 282-1, elevation 1,600 feet, 3 dextral; 282-3, elevation 1,550 feet, 10 dextral, all collected by Meinecke, 1933 (figs. 5, 5a, p. 105).

Out of 13 shells from area 84, 3 have pink color patterns similar to the shells of area 83. The remainder have a bluish-gray color pattern which differs from the forms of area 83a by having a yellowish ground color and the last whorl more strongly spirally lined.

The usual color pattern (pl. 3, fig. 4) has the embryonic whorls light buff; first half postembryonic light buff axially streaked with cinnamon buff, next whorl light cinnamon drab, last whorl and a half light buff axially streaked and faintly spirally lined with hair brown, also streaked with benzo brown; impressed sutural band light buff; lip and columella callus white, lip edged with avellaneous.

ACHATINELLA APEXFULVA GLAUCOPICTA, new subspecies

PLATE 3, FIGURE 10; PLATE 10, FIGURES 22, 22a

Achatinella apexfulva cervixnivea pattern Pilsbry and Cooke, Man. Conch., vol. 22, pp. 324, 328, pl. 60, fig. 9 (only), 1914.

The shell resembles the blue-gray color pattern of *A. a. lilacea* var. 1 but differs in having a sutural band which is always white, more bluish postembryonic whorls, stronger blue-gray axial streaks, and the ground pale gray instead of pinkish.

The embryonic whorls of the holotype (pl. 3, fig. 10) are white, postembryonic whorls white axially streaked with pale neutral gray and deep neutral gray; impressed sutural band white; lip and columella callus pale grayish vinaceous. Length 19.4 mm., greater diameter 13.1 mm., spire height 10.4 mm., number of whorls $6\frac{1}{4}$. The usual form was not determined for lack of specimens.

Distribution, area 87: **Central Poamoho Stream**, type locality 280K-2, elevation 1,250 feet, Meinecke, 1933; **Central Poamoho-Central Poamoho North Branch Ridge**, 280L-1, elevation 1,450-1,500 feet, 5 dextral and 1 sinistral, Meinecke, 1933 (figs. 5, 5a, p. 105).

The darkest color pattern (pl. 10, fig. 22) has the postembryonic whorls plumbeous axially streaked with white, dark violet gray, and blackish violet gray, last whorl almost solid blackish violet gray axially streaked by the above lighter shades of gray; impressed sutural band white; lip and columella callus light vinaceous fawn.

The usual form of a sinistral, shown on plate 10, figure 22a, has a color pattern similar to plate 3, figure 10, except that the dark axial streaks are finer and resemble those of *A. a. lilacea* var. 1 (pl. 3, fig. 3).

ACHATINELLA APEXFULVA PUNICEA, new subspecies

PLATE 2, FIGURE 26; PLATE 10, FIGURES 6-6c

The shape is similar to the probably lower race of *A. a. steeli*, but the color pattern is different. The color pattern resembles that of *A. a. lilacea*, but the range of color pattern and the form of the shell make it distinct from *lilacea*, which is a much smaller shell. The embryonic whorls of the holotype (pl. 2, fig. 26) are white, shading to pale pinkish buff on the last embryonic whorl; postembryonic whorls vinaceous buff axially streaked with avellaneous and tilleul buff; impressed sutural band light buff, tinting to pale pinkish buff on the last half whorl; lip and columella callus light vinaceous fawn lightening to white within. Length 19.0 mm., greater diameter 13.3 mm., spire height 9.6 mm., number of whorls 6.

Distribution, area 81??: **Kaukonahua**, Wilder, BBM 50583, 50581; also collected by O. P. Emerson on "Head gate road ridge between N. & S. br. of Kaukonahua," in the collection of the MCZ. The type locality is not known exactly. Odd specimens with the usual *A. a. punicea* pattern are found with *A. a. steeli* in locality 272. In the type lot a few blue-gray shells are found which are similar to *A. a. punicea* var. 1 (area 82?). The subspecies *A. a. punicea* probably exists somewhere between areas 80 and 82?, probably near the bottom of North Kaukonahua Stream, in the region of area 81?? (fig. 5a, p. 105).

An obese shell (pl. 10, fig. 6) measures: Length 19.4 mm., greater diameter 13.5 mm., spire height 8.9 mm.; embryonic whorls light buff; postembryonic whorls wood brown faintly axially streaked with tilleul buff, about the periphery a band of tilleul buff; impressed sutural band a hue between cinnamon and avellaneous; lip and columella callus pale vinaceous fawn. The pink color pattern of the holotype and plate 10, figure 6 occurs on 59 percent of the shells.

The sutural band may be white, the form elongate, and the color pattern a bluish pink (pl. 10, fig. 6a) intermediate between *A. a.*

punicca and *A. a. punicca* var. 1. The embryonic whorls are white; postembryonic whorls pale ecru drab axially streaked and faintly finely lined with pale brownish drab; lip and columella callus pale vinaceous fawn, the outer margin vinaceous fawn. Length 20.5 mm., greater diameter 13.0 mm., spire height 10.8 mm. This pattern is present on 39 percent of the shells. One specimen in the type lot is almost entirely white (pl. 10, fig. 6*b*), last whorl shaded with axial streaks of pale salmon color. In lot BBM 50581, out of seven shells, three are pinkish forms and three are bluish pink, and one has a yellowish pattern (pl. 10, fig. 6*c*); embryonic whorls light buff; postembryonic whorls light buff axially streaked with a dilute tint of pinkish cinnamon.

ACHATINELLA APEXFULVA PUNICEA var. 1

PLATE 2, FIGURE 27; PLATE 10, FIGURES 7-7*b*

Area 82?: **North-South Kaukonahua Ridge**, Lemke, BBM 115039, 1932, exact locality not accurately plotted but probably somewhere in the region of area 82?, but may have been collected at a higher or a lower elevation; also collected by Wilder, BBM 50578, but the shells have no locality label. Probably collected in or near area 82?, or in North Kaukonahua Stream (fig. 5*a*, p. 105).

The shell resembles *A. a. punicca* in form and size but differs in having a blue-gray color pattern similar to that of *A. a. glaucopicta*. A shell with the characteristic color pattern (pl. 2, fig. 27) has the first embryonic whorl and a half worn, colored cinnamon buff, remaining embryonic whorls pale pinkish buff; first postembryonic whorl white faintly axially streaked on the last half whorl with pale drab gray, penultimate whorl pallid mouse gray, finely axially streaked with white, and coarsely axially streaked on the last half with quaker drab, last whorl pallid mouse gray axially streaked with deep quaker drab, last fourth whorl hair brown axially streaked with fuscous; impressed sutural band white. Length 20.5 mm., greater diameter 13.3 mm., spire height 11.1 mm. The usual form of the shell was not obtainable owing to scarcity of material.

In the Wilder lot, BBM 50578, the lightest color pattern (pl. 10, fig. 7) has a pinkish tint and occurs on 17 percent of the shells. The postembryonic whorls shade from white to pale vinaceous fawn on the last two whorls, faintly lined and axially streaked with pale drab gray; impressed sutural band white. Length 18.5 mm., greater diameter 13.1 mm., spire height 9.0 mm. A sinistral shell (pl. 10, fig. 7*a*) has the embryonic whorls light buff; first postembryonic

whorl, below the white sutural and subsutural bands, light mouse gray, last whorl and a half pale vinaceous fawn axially streaked and faintly spirally lined with pale brownish drab; lip and columella callus pale vinaceous fawn. Forty-seven percent of the Wilder lot have yellow embryonic whorls. The darkest color pattern (pl. 10, fig. 7*b*), found on two shells, has the embryonic whorls white; post-embryonic whorls dark vinaceous drab axially streaked with drab gray, last half whorl mostly drab gray axially streaked with dark vinaceous drab; impressed sutural and subsutural bands white. The subsutural band, as in all specimens of this variety, decreases in width on each successive whorl so that it is lacking or merely a line on the last whorl.

ACHATINELLA APEXFULVA STEELI, new subspecies

PLATE 2, FIGURE 25; PLATE 10, FIGURES 3-5*c*

Achatinella apexfulva apicata NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 325, pl. 60, figs. 5*b*, 10, 1914.

The color pattern of the shell resembles *A. a. gulickii* but differs in being a larger shell with a dark reddish-brown color pattern. The embryonic whorls of the holotype (pl. 2, fig. 25) are pale pinkish buff; last half of the first postembryonic and penultimate whorls chocolate axially streaked and spirally banded with cinnamon drab, last whorl above the periphery light drab spirally lined and banded with chocolate, subperipheral band lilac buff, axially streaked with light drab and on the last half whorl streaked with avellaneous, base light drab axially streaked with white, spirally banded with natal brown and bone brown; lip and columella callus fawn color lightening to light vinaceous fawn on the inner margin. Length 19.3 mm., greater diameter 13.0 mm., spire height 10.2 mm., number of whorls 6½.

Distribution, area 80: **North-South Kaukonahua Ridge**, type locality 271, elevation 1,450-1,532 feet, Russ, 1933. Steel BBM 129017-129018, 6 sinistral 1934; also 272, elevation 1,500-1,550 feet, 1 dextral, 7 sinistral, Steel and Welch, 1934. Also collected by Gulick, O. H. Emerson, BBM 103972. Wilder, BBM 50577, 50580 (figs. 5, 5*a*, p. 105). This subspecies is named after Lt. Col. Charles L. Steel, U. S. A., who helped me determine the distribution of certain forms of *Achatinella* and generously gave me valuable material.

The obese form of the shell (pl. 10, fig. 3) measures: Length 19.3 mm., greater diameter 13.5 mm., spire height 10.0 mm.; embryonic whorls pale pinkish cinnamon, lightening to white on the last embryonic whorl; first half postembryonic whorl cinnamon buff axially

streaked with mikado brown, remaining whorls chocolate, faintly axially streaked with pinkish buff, spirally lined on the upper third of the whorl above the periphery with a line of light drab and cinnamon, on the last half whorl above the periphery the chocolate ground color changing to buffy brown or olive brown axially streaked and banded with a band of bone brown, below the periphery a band of cartridge buff and a band of chocolate, the remainder of the base cartridge buff spirally lined with drab gray and two bands of natal brown in the umbilical region.

In the lot collected by Steel from locality 271 a gray color pattern is found (pl. 10, fig. 4); postembryonic whorls light drab axially streaked with hair brown, fuscous, benzo brown, and faintly spirally lined with fine lines of fuscous and white, below the periphery of the last whorl the ground white, shaded with pale gull gray and spirally banded with a band and a line of light drab axially streaked with fuscous, in the umbilical region a line and a band of fawn color.

In the Wilder collection, mixed with color patterns of typical *A. a. steeli*, are a series of color patterns which have the base white or banded with white below the periphery and contain dextral as well as sinistral shells. The shells may be typical *A. a. steeli* or they may come from a different area.

The usual form of a dextral shell and a characteristic color pattern in this lot (pl. 10, fig. 5) has the embryonic whorls cartridge buff; postembryonic whorls pecan brown, spirally ornamented on the last whorl and a half with a white band or line, below the impressed pecan brown sutural band and in the center of the whorl above the periphery, edge of the periphery banded with a wide white band, at the upper edge of which is a line of pecan brown, remainder of the base white with a central band and a line of pecan brown, in the umbilical region a patch of fawn color; lip and columella callus pale vinaceous fawn, outer margin spotted with fawn. Length 20.0 mm., greater diameter 13.0 mm., spire height 10.6 mm.

The base may be entirely white (pl. 10, fig. 5a) faintly shaded with vinaceous fawn and lined with a line of army brown in the umbilical region; the postembryonic whorls above the periphery are similar to plate 10, figure 5, only more axially streaked and spirally lined with white. A narrow sinistral specimen (pl. 10, fig. 5b) measures: Length 18.4 mm., greater diameter 12.2 mm., spire height 9.7 mm. An obese shell (pl. 10, fig. 5c) measures: Length 18.0 mm., greater diameter 13.6 mm., spire height 9.0 mm. The shells of figures 5b and 5c have a similar color pattern to the shell of plate 10, figure 3.

ACHATINELLA APEXFULVA STEELI var. 1

PLATE 2, FIGURE 24; PLATE 10, FIGURES 1-2

Area 79: North-South Kaukonahua Ridge, locality 270, elevation 1,450 feet, 3 dextral, dead specimens, Steel and Welch, BBM 129012, 1934; "Mauka [toward the mountains] of the Burnt District, Kaukonahua," Thurston, BBM 130674. The burnt district is in the region of area 78?, on the North-South Kaukonahua Ridge. Also collected by Wilder, BBM 10446, Lemke, BBM 115036, Gulick, BBM 10445 (figs. 5, 5a, p. 105).

This variety may be a distinct subspecies separable from *A. a. steeli* by having a distinctly lighter color pattern. The Welch lot of three shells indicates this possibility, but in all other lots the variety is found mixed with *A. a. steeli*. Therefore, until more careful collecting is done in area 79 and this race is definitely proved to be a distinct race and not a light color pattern of the shells of area 80, this form is considered a variety of *A. a. steeli*.

The usual form and color pattern of the shell (pl. 2, fig. 24) has the embryonic whorls pale pinkish buff; the upper half of the first two postembryonic whorls including the impressed sutural band cameo brown, lower half white, banded just above the edge of the periphery with a band of vinaceous buff lined with army brown, this band fading to white on the last half of the penultimate, the last whorl white, sutural and subsutural bands chocolate, subsutural band lined with pale pinkish cinnamon, below the subsutural band a band of tawny lined with russet, above the peripheral line of tawny the white supraperipheral band shaded with cinnamon buff, below the periphery the ground white banded with army brown, base finely lined with pale brownish drab; lip outer margin vinaceous fawn, inner margin and columella callus white. Length 18.8 mm., greater diameter 12.8 mm., spire height 9.8 mm., number of whorls $6\frac{1}{2}$.

A narrow form with a narrow sutural band (pl. 10, fig. 1) has the embryonic whorls white; postembryonic whorls white, banded below the burnt umber sutural band with a band of white, burnt umber, and sayal brown, on the last whorl the sayal brown band lightening to cinnamon buff and fading out on the last half whorl, the white ground shaded by faint bands of pinkish buff, base lined with fawn color. Length 18.3 mm., greater diameter 12.0 mm., spire height 10.4 mm.

A sinistral specimen (pl. 10, fig. 1a) resembles the pattern of plate 2, figure 24, on the first two postembryonic whorls; last whorl pale pinkish cinnamon, below the subsutural bands of chocolate and pinkish cinnamon, spirally banded at and above the periphery with

light buff which deepens to warm buff on the last whorl, below the periphery base banded with a band of cinnamon drab, benzo brown and cream color in the umbilical region.

A possible intermediate pattern between *A. a. versicolor* var. 1 and *A. a. steeli* var. 1 (pl. 10, fig. 1b) is seen on three specimens in the Wilder collection; embryonic whorls white; postembryonic whorls banded at the suture and below the suture by a wide band of chestnut brown covering the upper half of the whorl, which is solid or lined with drab gray, just above the edge of the periphery a band of pale ecru drab axially streaked with white and spirally lined with light brownish drab, just below the edge of the periphery a band of white and below this a band of natal brown, base white, shaded with ecru drab and lined with a line of light brownish drab.

In the Thurston lot there is a very light color pattern (pl. 10, fig. 2). The embryonic whorls are pale pinkish cinnamon; first postembryonic whorl pale pinkish cinnamon, banded with bone brown, and cinnamon, penultimate and last whorl white, banded above or at the edge of the periphery with a narrow band of bone brown lightening to army brown, above the peripheral band a faint band of cinnamon buff, below the periphery the ground white lined and banded with avellaneous; lip and columella callus avellaneous lightening to white toward the inner margin. Before the Thurston collection was given to the Bishop Museum the cabinets containing the collection were moved during a fire. In moving the cabinets they were tilted and shells from different localities were mixed. Therefore the exact location of this light color form should be checked.

GROUP OF *A. a. APICATA* NEWCOMB

***ACHATINELLA APEXFULVA BRUNOSA*, new subspecies**

PLATE 3, FIGURE 11; PLATE 10, FIGURES 26-28

This species is similar to *A. a. lilacea* var. 1 (area 83) in form, in the width of the axial streaks on the postembryonic whorls, and in usually having a white sutural band. It differs in having the last whorl and a half gray or gray brown. *A. a. brunosa* also closely resembles *A. a. apicata*, but differs in the shade of brown of the postembryonic whorls, and in usually having a white sutural band.

The first two postembryonic whorls of the holotype (pl. 3, fig. 11) are cinnamon pink, deepening on the last embryonic whorl to ochraceous buff, first half postembryonic whorl army brown axially streaked with white, next whorl axially streaked with pale gull gray and deep neutral gray, next half whorl finely axially streaked with

hair brown, and smoke gray, last whorl drab finely axially streaked with hair brown; impressed sutural band upper two-thirds white, lower third the color of the whorl below; lip and columella callus light vinaceous fawn. Length 18.9 mm., greater diameter 12.3 mm., spire height 10.8 mm., number of whorls 6.

Distribution, area 88: **Central Poamoho-Central Poamoho North Branch Ridge**, type locality 280L-2, elevation 1,550 feet; also 280L-3, elevation 1,600-1,650 feet, 2 dextral, 5 sinistral, Meinecke, 1933; 280L-4, elevation 1,700 feet; 280L-5, elevation 1,650 feet, 18 sinistral, all Meinecke-collected, 1933 (figs. 5, 5a, p. 105).

An extremely narrow shell (pl. 10, fig. 26) shows a lighter color pattern; first half postembryonic whorl army brown axially streaked with white, next whorl axially streaked with hair brown, benzo brown, white, and pale pinkish cinnamon, first half of last whorl the ground above the periphery pale pinkish cinnamon darkening on the last half whorl and below the periphery to a yellowish hue of wood brown, the entire whorl axially streaked with snuff brown and warm sepia; impressed sutural band white. Length 18.5 mm., greater diameter 11.6 mm., spire height 10.5 mm.

On one specimen the sutural band is found to be mikado brown on the last two whorls. This obese shell (pl. 10, fig. 26a) resembles more the form and color pattern of *A. a. suturafusca* var. 2 (pl. 10, fig. 25b). The first two postembryonic whorls and the last whorl above the periphery pallid mouse gray or mouse gray axially streaked with dark purple drab, last whorl below the periphery snuff brown on the last half of the whorl, last whorl below the periphery sayal brown axially streaked with bister or benzo brown. Length 20.0 mm., greater diameter 13.4 mm., spire height 11.2 mm.

The usual form of a sinistral and a grayish pattern (pl. 10, fig. 27) has the penultimate and first half of last whorl drab gray axially streaked with pale drab gray or white, last half of last whorl light drab darkening to drab axially streaked with hair brown and snuff brown, just above the edge of the periphery a line of white. Length 18.2 mm., greater diameter 12.1 mm., spire height 9.9 mm.

The color pattern of a sinistral (pl. 10, fig. 28) shows the darkest brownish color pattern with the usual fine axial streaks, of the subspecies. The first half of the first postembryonic whorl cinnamon buff, faintly axially streaked with army brown, last half livid brown lightly axially streaked with pallid mouse gray, penultimate whorl light mouse gray deepening to mouse gray, and axially streaked with

deep mouse gray, last whorl drab axially streaked with hair brown and fuscous, last fourth whorl sepia.

ACHATINELLA APEXFULVA SUTURAFUSCA, new subspecies

PLATE 3, FIGURE 9; PLATE 10, FIGURES 24, 24a

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 326, pl. 60, fig. 7b (only), 1914.

The shell resembles the form of *A. a. glaucopicta* but has a brown sutural band and yellow embryonic whorls. The first two embryonic whorls of the holotype (pl. 3, fig. 9) warm buff deepening to ochraceous buff on the last embryonic whorl; first half of first post-embryonic whorl white, next whorl and a half lilac gray axially streaked with violet gray, last whorl pale mouse gray axially streaked with deep mouse gray and tilleul buff, and faintly spirally lined with deep mouse gray with a spiral band of tilleul buff just above the edge of the periphery, last fourth whorl tilleul buff axially streaked with army brown; impressed sutural band chestnut; lip and columella callus pale vinaceous fawn. Length 19.1 mm., greater diameter 13.5 mm., spire height 9.3 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 86: **Central Poamoho Stream**, type locality 280K-1*, elevation 1,150-1,250 feet, Meinecke, 1932 (figs. 5, 5a, p. 105). Also collected by O. H. Emerson, BBM 102289, Wilder, BBM 50586. The Wilder shells are labeled North Kaukonahua, probably an error for Central Poamoho Stream.

The lightest color pattern (pl. 10, fig. 24), found on only three specimens, has the first two postembryonic whorls white, the penultimate axially streaked with pale drab gray, last whorl a dilute shade of pale drab gray or white axially streaked with drab gray and faintly spirally banded, below the chestnut sutural band, with a wide band of a dilute shade of pale quaker drab, and a band of tilleul buff at the edge of the periphery.

The usual form and color pattern of a sinistral shell (pl. 10, fig. 24a) also exhibits the dark color pattern of a dextral shell, embryonic whorls ochraceous tawny; first postembryonic whorl light neutral gray axially streaked with white, penultimate whorl light neutral gray axially streaked with neutral gray and deep neutral gray and finely spirally lined with lines of deep neutral gray, last whorl mouse gray axially streaked and faintly spirally lined with deep mouse gray; impressed sutural band chestnut. Length 18.1 mm., greater diameter 12.3 mm., spire height 9.6 mm.

ACHATINELLA APEXFULVA SUTURAFUSCA var. 1

PLATE 3, FIGURE 1; PLATE 10, FIGURE 23

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 326, pl. 60, fig. 7a (only), 1914.

Area 85: **South Poamoho Stream**, locality 280-7, elevation 1,300-1,350 feet, Welch and C. W. Isle, 8 sinistral 1935 (figs. 5, 5a, p. 105).

The form is close to typical *A. a. suturafusca*, but differs in having a mars brown impressed sutural band, and the postembryonic whorls not colored with as bluish-gray streaks as *A. a. suturafusca*. Moreover, the dark color pattern (pl. 10, fig. 23) is not known to me from area 86.

The light color form (pl. 3, fig. 1) has the embryonic whorls tawny; first fourth postembryonic whorl tawny, the remaining whorls tillule buff or pale drab gray axially streaked with deep mouse gray and mouse gray, the last two whorls faintly spirally lined with deep mouse gray; lip and columella callus light grayish vinaceous. Length 19.8 mm., greater diameter 13.1 mm., spire height 10.6 mm. So few specimens are known from this area that the usual form and color pattern is not determined.

The dark color pattern (pl. 10, fig. 23) has the embryonic whorls amber brown; postembryonic whorls clove brown or black axially streaked with drab gray, last eighth whorl verona brown; impressed sutural band bone brown or black. Length 18.1 mm., greater diameter 12.7 mm., spire height 9.0 mm.

ACHATINELLA APEXFULVA SUTURAFUSCA var. 2

PLATE 3, FIGURE 13; PLATE 10, FIGURES 25-25d

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 326, pl. 60, figs. 4, 7(?) (only), 1914.

Area 89: **North Poamoho Stream**, locality 290*, elevation 1,300 feet, Meinecke, 1914, 1917, 4 dextral, 8 sinistral 1926; **Wahiawa**, Gulick, ANSP 92628 (figs. 5, 5a, p. 105).

This race is very similar to *A. a. suturafusca* (area 86) but differs in usually having a more purplish-gray or darker color pattern. Brownish color forms similar to *A. a. apicata* also occur in area 89 but not in area 86. The form also resembles *A. a. suturalba* but differs in having a brown sutural band. This variety is an intermediate one between *A. a. apicata* and *A. a. suturalba*.

The usual form and color pattern (pl. 3, fig. 13) has the embryonic whorls ochraceous tawny; first fourth postembryonic whorl cinnamon drab axially streaked with tilleul buff, next whorl and a fourth gull gray axially streaked and finely lined with vinaceous slate, last half of penultimate and first fourth of last whorl gull gray heavily axially streaked and finely lined with dusky drab, the second fourth of last whorl dark livid brown, last half whorl cinnamon drab axially streaked with deep brownish drab and faintly spirally banded or tinged with a faint tint of dark heliotrope gray; impressed sutural band pale ochraceous buff on the first two whorls spotted with cinnamon buff, on the last whorl the color is cinnamon; lip and columella callus light vinaceous fawn. Length 20.0 mm., greater diameter 13.1 mm., spire height 11.2 mm., number of whorls $6\frac{1}{2}$.

The darkest color pattern (pl. 10, fig. 25) and the obese form of the shell has the first three-fourths postembryonic whorl axially streaked with gull gray and dusky brown, the next or last whorl and a half is almost solid dusky brown with faint axial streaks and spiral lines of light quaker drab which are almost obsolete; impressed sutural band burnt umber. Length 18.8 mm., greater diameter 13.8 mm., spire height 9.3 mm. An extreme narrow shell and light grayish-brown pattern (pl. 10, fig. 25a) has the first postembryonic whorl and a half pale smoke gray axially streaked and faintly spirally lined with light grayish olive, the last whorl pale smoke gray spirally lined and axially streaked with hair brown, last one-fourth whorl tilleul buff axially streaked with verona brown. Length 17.8 mm., greater diameter 11.2 mm., spire height 10.2 mm.

Meinecke first collected locality 290* in 1914 and obtained 109 shells, 93 percent of which are dextral. In 1917 he again went to the same region and collected 83 shells, 86 percent of which are sinistral. Since all Meinecke's plotting before 1933 is done from memory it is probable that these two lots represent slightly different localities. The sinistral lot appears to have more bluish forms than the lot of dextral shells. The usual dextral color patterns resemble typical *A. a. apicata*. It is possible that the dextral locality may be one closer to the area of *A. a. apicata* than the sinistral lot and so transitional specimens between the two forms are found.

The usual form of a dextral (pl. 10, fig. 25b) has the embryonic whorls ochraceous tawny; first postembryonic whorl and a half axially streaked with natal brown and pallid mouse gray, last whorl and a half hay's brown, axially streaked with tilleul buff, and sorghum brown and faintly spirally lined with benzo brown; impressed sutural band cinnamon; lip and columella callus a very dilute tint of pale

vinaceous fawn. Length 19.6 mm., greater diameter 13.1 mm., spire height 10.8 mm.

A narrow dextral and light bluish pattern (pl. 10, fig. 25c) has the first half postembryonic whorl pale ochraceous salmon, axially streaked with pale vinaceous fawn, next whorl and a half light neutral gray spirally lined and streaked with pale gull gray, on the last half whorl ground color pallid neutral gray almost covered over with closely set axial streaks of light purplish gray and purplish gray; impressed sutural band cinnamon, darkening to mikado brown on the last whorl. Length 19.8 mm., greater diameter 12.7 mm., spire height 11.1 mm.

One specimen was found with a pinkish pattern (pl. 10, fig. 25d), the last whorl and a half seashell pink streaked and spirally lined and banded with light mouse gray. This color pattern is found in lots of shells collected by Gulick, Thurston, and others. Possibly there is an intermediate region between areas 89 and 93 where *A. a. suturafusca* var. 2 intergrades with *A. a. cerzixnivea*.

ACHATINELLA APEXFULVA SUTURALBA, new subspecies

PLATE 3, FIGURE 12; PLATE 10, FIGURES 29, 29a

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, p. 325, pl. 60, fig. 4b (only), 1914.

The form resembles *A. a. suturafusca* but differs in usually having a white sutural band instead of a brown sutural band. Gulick collected this form, but his lot (ANSP) contains a mixture of *A. a. suturafusca* var. 2 and *A. a. suturalba*. His material is probably a mixture of shells from areas 89 and 90 together with some intermediate localities between these two areas.

The embryonic whorls of the holotype (pl. 3, fig. 12) ochraceous tawny; first two postembryonic whorls axially streaked with pallid mouse gray, white, deep quaker drab, and quaker drab, last whorl axially streaked with dark vinaceous drab, pale drab gray, and on the last fourth of the whorl deep brownish drab; lip and columella callus white or faintly tinged with a pinkish shade, possibly pale vinaceous fawn. Length 19.4 mm., greater diameter 13.2 mm., spire height 10.8 mm., number of whorls 6 $\frac{2}{3}$.

Distribution, area 90: **North Poamoho Stream**, type locality 290AA-8, elevation 1,150-1,200 feet, Lemke and Welch, 1935; also locality 290AA-5, elevation 1,150 feet, 1 dead dextral, Welch, BBM 132753, 1935; 291A-2, elevation 1,150 feet, 1 dead dextral, Welch, BBM 165914, 1935; **Central Poamoho Stream**, locality 280AA-2,

elevation 1,100 feet, 3 dead dextral, Welch, BBM 132771, 1935; also collected by Wilder, BBM 50636, Gulick, ANSP 98628C (figs. 5, 5a, p. 105).

The lightest color pattern found on only two specimens is shown on plate 10, figure 29; last two postembryonic whorls axially streaked with white, neutral gray, and deep neutral gray; impressed sutural band and also the subsutural band, which disappears on the last half whorl, white axially streaked with seashell pink; lip and columella callus light vinaceous fawn.

A narrow shell (pl. 10, fig. 29a) and a dark color pattern lacks the usual white sutural band; postembryonic whorls chaetura black axially streaked with white, or tilleul buff; impressed sutural band tilleul buff streaked with avellaneous. Length 20.0 mm., greater diameter 12.2 mm., spire height 12.1 mm. This form with a colored sutural band occurs on five specimens in the combined Lemke and Welch lots of 45 shells exhibiting the color pattern. Fifty-one percent have a white sutural band, the rest a tinted sutural band similar to that of figures 29 or 29a.

ACHATINELLA APEXFULVA SUTURALBA var. 1

PLATE 3, FIGURE 19

Area 91???: **Helemano**, J. S. Emerson, BBM 102298-102299, also Gulick. Possibly this race occurred in the South Helemano opposite area 90 in area 91?? (fig. 5a, p. 105). No specimens have been found in recent years.

This variety is similar to *A. a. suturalba* but has a wider band of white about the suture and never has a dark or a pinkish sutural band similar to that of plate 10, figures 29 and 29a. The usual form (pl. 3, fig. 19) has the embryonic whorls ochraceous tawny; postembryonic whorls pallid neutral gray axially streaked and faintly spirally lined with deep neutral gray, on the last half whorl the streaks are deep purplish gray; sutural and subsutural bands white; lip and columella callus tilleul buff. Length 18.8 mm., greater diameter 12.2 mm., spire height 10.6 mm.

ACHATINELLA APEXFULVA APICATA (Newcomb) Pfeiffer

PLATE 3, FIGURE 14; PLATE 11, FIGURES 2, 3

Achatinella apicata (Newcomb) PFEIFFER, Proc. Zool. Soc. London, 1855, p. 210.

Achatinella apexfulva apicata (Newcomb) PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp 324, 325, 328, pl. 60, figs. 4a, 4c (only), 1914.

There are two specimens of *A. a. apicata* in the type lot. One of them marked "A" by me (pl. 11, fig. 2) is considered the lectotype.

The embryonic whorls are ochraceous buff shading to ochraceous tawny, penultimate whorl pale drab gray axially streaked with mouse gray, last whorl vinaceous buff axially streaked with verona brown, last half whorl streaked with russet, last whorl at the edge of the periphery has a line of light vinaceous buff; lip light vinaceous fawn. Length 20.5 mm., greater diameter 12.8 mm., number of whorls $6\frac{1}{2}$.

Distribution, area 92: **Helemano**, Gulick; **Poamoho-Helemano Ridge**, locality 300E, elevation 1,250-1,300 feet, H. Lemke; **Wahiawa**, Gulick (fig. 5a, p. 105). Lectotype, BM.

The usual form in the Gulick collection (pl. 3, fig. 14) has the embryonic whorls ochraceous tawny; first three-fourths postembryonic whorl tulle buff axially streaked with vinaceous fawn, remaining whorls with ground color of pale pinkish cinnamon darkening on the last whorl to light pinkish cinnamon, and pale pinkish cinnamon on the last half whorl, axially streaked on the penultimate with army brown, benzo brown, and shaded or streaked with pale drab gray, the first half of the last whorl streaked and sparsely lined with brownish drab, last half whorl strongly streaked with army brown or walnut brown, just above the edge of the periphery of the last whorl a white line or band; lip and columella callus vinaceous buff. Length 19.7 mm., greater diameter 12.8 mm., spire height 11.2 mm., number of whorls $6\frac{3}{4}$.

On an obese shell with wide axial streaks (pl. 11, fig. 3) the embryonic whorls are ochraceous tawny; ground of the postembryonic whorls pale ochraceous salmon deepening on the last whorl to light ochraceous salmon, and axially streaked or shaded with army brown, fawn, or light drab, on the last whorl above the periphery a faint line of pale ochraceous salmon, base spirally banded with light buff; impressed sutural band russet. Length 19.1 mm., greater diameter 13.3 mm., spire height 10.4 mm.

ACHATINELLA APEXFULVA APICATA var. 1

PLATE 3, FIGURE 20; PLATE 11, FIGURES 4-7a

Area 95: **North-South Helemano Ridge**, locality 312-2, elevation 1,550 feet; 312-3, elevation 1,500-1,600 feet, 6 dextral; 312-4, elevation 1,600-1,650 feet; 312-5, elevation 1,650 feet, Meinecke, 1933; 310*, elevation 1,400-1,450 feet, 1932; 311*, elevation 1,450-1,500 feet, 1932; 312-2-4*, 1932, all collected by Meinecke. All the 1932 localities are plotted from memory and may be too low (figs. 5, 5a, p. 105).

The shell is similar to *A. a. apicata* but differs in having the usual form narrower; the usual color pattern finely streaked with grayish

brown instead of widely streaked with reddish brown; sutural band the same color as the rest of the whorl; ground color not as pinkish as some specimens of *A. a. apicata* (pl. 11, fig. 3). The embryonic whorls of the usual form (pl. 3, fig. 20) are worn and are best described from another specimen; postembryonic whorls tulleul buff finely axially streaked with hair brown, benzo brown, fuscous, and a few streaks of natal brown, on the last half whorl the ground color shaded with mouse gray, streaked with fuscous; impressed sutural band wood brown; lip and columella callus vinaceous fawn. Length 19.0 mm., greater diameter 12.0 mm., spire height 10.9 mm., number of whorls $6\frac{1}{4}$.

An obese form (pl. 11, fig. 4) has ochraceous tawny embryonic whorls; first fourth postembryonic whorl tawny faintly streaked with ochraceous tawny, last half whorl pale pinkish cinnamon axially streaked with drab gray and cinnamon drab, penultimate whorl tulleul buff axially streaked with hair brown, benzo brown, and natal brown, first half of last whorl tulleul buff, shaded with drab gray, axially streaked with hair brown and natal brown, last half whorl drab axially streaked with tulleul buff, fuscous, and dark vinaceous brown at and below the periphery lined with pale drab gray; impressed sutural band the same as the rest of the whorl. Length 19.4 mm., greater diameter 13.2 mm., spire height 10.3 mm.

A light brownish specimen (pl. 11, fig. 5) resembles *A. a. apicata*, but differs in not having a brown sutural band distinct from the rest of the whorl and in having a color pattern with a shade of brown not found on *A. a. apicata*. The postembryonic whorls are pale ochraceous buff, strongly axially streaked with tawny olive and a few streaks of warm sepia.

Throughout area 96, odd specimens (pl. 11, fig. 6) occur of an entirely different pattern. The shell has the usual embryonic whorls; postembryonic whorls light pinkish cinnamon banded and mottled and lined with chocolate, the bands broken in places by the ground color; lip and columella callus light vinaceous fawn.

One specimen (pl. 11, fig. 7) has the first two postembryonic whorls with the usual color pattern of plate 11, figure 4, and the last half similar to plate 11, figure 6.

Another shell (pl. 11, fig. 7a) looks as if it were diseased, the first fourth postembryonic whorl cinnamon axially streaked with cinnamon buff, the next whorl and three-quarters warm blackish brown faintly streaked with pale drab gray, resembling *A. a. apicata* var. 1, last three-fourths whorl white spirally banded or spotted with tawny and might be taken for a faded color pattern of figure 6.

ACHATINELLA APEXFULVA APICATA var. 2

PLATE 3, FIGURE 23; PLATE 11, FIGURES 14-16d

Area 96: **Kawaihalona Gulch**, locality 324, elevation 1,450 feet, 4 dextral 1933; 325, elevation 1,500-1,600 feet, 4 dextral 1933; 326*, elevation 1,600-1,650 feet, 3 dextral 1932, all collected by Meinecke. Other collectors of *A. a. apicata* var. 2 in Kawaihalona Gulch are Wilder, BBM 50509-50510, Cheatham in Thurston collection, BBM 130851. The material is unlocalized and probably is a mixture of several races (figs. 5, 5a, p. 105).

Very little accurate information is available on the shells of Kawaihalona. From the data on hand it appears that the characteristic pattern is similar to plate 3, figure 23. Embryonic whorls a dark shade of ochraceous buff; first fourth postembryonic whorl tawny axially streaked with ochraceous buff, remaining postembryonic whorls pale pinkish buff darkening to light buff, strongly axially streaked and spirally lined or banded with hair brown or fuscous; impressed sutural band the color of the rest of the whorl; lip and columella callus pale vinaceous fawn. Length 19.2 mm., greater diameter 13.2 mm., spire height 10.7 mm., number of whorls 6+.

A darker banded pattern (pl. 11, fig. 14) has the postembryonic whorls dark vinaceous brown axially streaked and banded and lined with pallid mouse gray changing on the last fourth whorl to tulle buff. The base of this specimen is flattened.

Besides the above patterns, which have been checked by dead specimens collected by Meinecke in area 96, a color pattern (pl. 11, fig. 15) similar to *apicata* var. 1 (pl. 11, fig. 4) is found in locality 326. The embryonic whorls are light buff deepening to warm buff; postembryonic whorls pale vinaceous fawn axially streaked with cinnamon drab and bone brown, last whorl with a line of pale vinaceous fawn above, below, and at the edge of the periphery.

In the Wilder collection, lot BBM 50510 had no locality label on the shells when it came into the Bishop Museum. The lot may be a mixture, for shells with color patterns similar to *A. a. suturafusca* var. 2 (pl. 3, fig. 13) and other patterns are found mixed in with what I suppose may be shells from Kawaihalona, because the color pattern of plate 3, figure 23, occurs in the lot, and because of the position of the lot in the Wilder collection when first received by the Museum. Although the locality data are faulty and should be checked, some peculiar patterns occur in this lot which are worthy of note since they are not recorded from any plotted locality today.

Plate 11, figure 16, is a color pattern similar to plate 11, figure 15, except that it is banded on the last whorl above and below the periphery with a band of pale ochraceous buff which is the ground color. The shell may have a zigzag pattern (pl. 11, fig. 16a), the postembryonic whorl hay's brown or sorghum brown, axially streaked with straight or zigzag streaks of pale mouse gray. An extreme narrow shell (pl. 11, fig. 16b) with a more marked zigzag pattern measures: Length 19.0 mm., greater diameter 11.9 mm., spire height 10.6 mm.; postembryonic whorls warm blackish brown, axially streaked with zigzag lines of warm buff. Another specimen (pl. 11, fig. 16c) shows another form of a narrow shell with a flattened base; postembryonic whorls chestnut faintly axially streaked or splotched with warm buff; impressed sutural band warm buff. Length 18.8 mm., greater diameter 12.0 mm., spire height 10.6 mm.

But by far the most unusual pattern, with the exception of patterns 16b and 16c, is the shell of plate 11, figure 16d. The embryonic whorls are a deep shade of ochraceous buff; postembryonic whorls fawn color sparsely axially streaked with pale ochraceous buff; impressed sutural band fawn color. This color pattern may be a pure race somewhere, possibly in the North Helemano or the South Helemano at a low elevation below area 95. It looks very much like typical *A. a. apicata*.

ACHATINELLA APEXFULVA PAALAENSIS, new subspecies

PLATE 3, FIGURE 21; PLATE 12, FIGURE 20

The shell is related to *A. a. apicata* var. 1 but differs in having a blue-gray color pattern instead of a brown one. The holotype (pl. 3, fig. 21) has the embryonic whorls ochraceous tawny; first half post-embryonic whorl mikado brown axially streaked with white, remaining whorls white axially streaked with light gull gray, and light neutral gray; impressed sutural band the color of the ground, except on the last half whorl where it is shaded with cinnamon drab; lip and columella callus light vinaceous fawn. Length 18.1 mm., greater diameter 12.1 mm., spire height 9.7 mm., number of whorls 6+.

Distribution, area 106: **North-South Helemano Ridge**, type locality 313-3, elevation 1,600-1,700 feet, 1933; **South Helemano Stream**, locality 301c, elevation 1,350-1,400 feet, 4 dextral, Meinecke, 1933 (figs. 5, 5a, p. 105).

The color pattern in area 106 may be darker (pl. 12, fig. 20) and the form narrower than the holotype; last two and a half post-embryonic whorls pale gull gray axially streaked with deep mouse

gray and dark mouse gray, below the periphery a line of dark mouse gray, the entire last whorl faintly lined with a light shade of deep mouse gray; outer margin of the lip vinaceous fawn, inner edge and the columella callus white. Length 18.0 mm., greater diameter 11.8 mm., spire height 9.7 mm.

ACHATINELLA APEXFULVA PAALAENSIS var. 1

PLATE 12, FIGURES 21-22*b*

Area 107: **North-South Helemano Ridge**, locality 313-1, elevation 1,700-1,800 feet, 6 dextral 1933; 314-1, elevation 1,650-1,750 feet, 1932, 1933; 315-2, elevation 1,800-1,864 feet, 7 dextral 1933; 315-3, elevation 1,800 feet, 1 dextral 1933; 316-1, elevation 1,750-1,800 feet, 1933, 4 dextral 1934; 316-3, elevation 1,700-1,800 feet, 5 dextral 1933, 3 dextral 1934; 316-1-3, 1932, all Meinecke-collected; **Kawaihalona-Opaepala Ridge**, locality 332*, elevation 1,700-1,850 feet, Russ, 2 dextral 1931, Meinecke, 1 dextral 1932; **Helemano-Opaepala Ridge**, 334, elevation 1,450 feet, 1932, 1934; 336-1*, elevation 1,850 feet, 1929; 336-2, elevation 1,800-1,850 feet, 1 dextral 1934, all Meinecke-collected. Also collected by O. H. Emerson, BBM 103977-103982, J. S. Emerson, BBM 102291 (figs. 5, 5*a*, p. 105).

Throughout this region the shells are a mixture of blue-gray forms and pinkish blue-gray or pink color patterns. The usual color pattern and form of the shell on the North-South Helemano Ridge (pl. 12, fig. 21), has the embryonic whorls ochraceous buff; first half of first postembryonic whorl axially streaked with vinaceous cinnamon and pale pinkish buff, next whorl and a half white axially streaked with vinaceous brown, and dark vinaceous brown with a spiral band of dark vinaceous gray on the last half of the penultimate on the upper third of the whorl, last whorl white or pale vinaceous fawn, and heavily streaked with light vinaceous drab, dark vinaceous drab and faintly spirally lined and banded with light quaker drab; lip and columella callus light vinaceous fawn. Length 19.9 mm., greater diameter 12.7 mm., spire height 11.1 mm.

The shell may be bluish gray (pl. 12, fig. 21*a*); last two and a half postembryonic whorls white or a very dilute tint of pallid quaker drab axially streaked with mouse gray and deep quaker drab. A narrow shell and light pink color pattern (pl. 12, fig. 21*b*) has the penultimate whorl axially streaked with white and vinaceous cinnamon, first half of last whorl axially streaked with white and buff pink and a faint band above the periphery of light cinnamon drab, last half of last whorl light russet vinaceous deepening to light brownish drab on the

last fourth of the whorl, axially streaked with a color lighter than the ground and spirally banded and lined with light brownish drab. Length 19.7 mm., greater diameter 12.7 mm., spire height 10.5 mm.

The shape of the usual form and color pattern (pl. 12, fig. 22) of the shell on the Kawaihalona-Opacula Ridge or the Helemano-Opacula Ridge is more elongate and the color pattern darker. The embryonic whorls are ochraceous buff; postembryonic whorls vinaceous pink axially streaked and faintly spirally banded with benzo brown; lip and columella callus light vinaceous fawn. Length 20.0 mm., greater diameter 12.5 mm., spire height 11.3 mm. An obese shell with a light pinkish-gray pattern (pl. 12, fig. 22a) has pale vinaceous fawn postembryonic whorls axially streaked and faintly banded with drab gray or light drab. Length 19.6 mm., greater diameter 13.3 mm., spire height 10.4 mm.

In the lot collected at locality 334 in 1932 by Meinecke a few narrow yellowish-brown shells (pl. 12, fig. 22b) are found. This pattern possibly belongs to a lower race, but until more is known about this color form it will be considered to be *A. a. paalaensis* var. 1. The embryonic whorls are ochraceous buff; postembryonic whorls light pinkish cinnamon axially streaked with light drab, and drab on the first two whorls, last whorl axially streaked with saccardo's umber and snuff brown, on the last two whorls above the periphery a band of white or a dilute tint of pale pinkish buff, below the periphery of the last whorl a line of snuff brown; lip and columella callus light vinaceous fawn. Length 19.6 mm., greater diameter 12.0 mm., spire height 11.4 mm.

ACHATINELLA APEXFULVA PAALAENSIS var. 2

PLATE 3, FIGURE 24

Area 109: **Helemano-Opacula Ridge**, locality 337-1, elevation 1,800-1,850 feet, 1934; 337-2, elevation 1,800-1,900 feet, 1934; 337-3, elevation 1,750-1,900 feet, 1934, Meinecke; 337-1-2?, Meinecke, BBM 122320-122321, 1929; 337-1-3?, Meinecke, BBM 122268-122269, 1928, BBM 122362-122368, 1932. Also collected by Wilder, BBM 50513-50517, O. H. Emerson, BBM 103985 (figs. 5, 5a, p. 105).

In area 109 the pink-streaked pattern of *paalaensis* var. 1 becomes dominant over the bluish-gray pattern. The usual form and color pattern (pl. 3, fig. 24) has the usual ochraceous buff embryonic whorls; first half postembryonic whorl axially streaked with ochraceous tawny and pale cinnamon pink, next two whorls pale ochraceous salmon axially streaked with russet vinaceous, last half whorl cameo brown

with a few axial streaks of light vinaceous cinnamon and a faint band of white at the periphery; lip, sutural and subsutural bands light vinaceous fawn. Length 20.0 mm., greater diameter 12.7 mm., spire height 10.7 mm., number of whorls $6\frac{1}{2}$.

ACHATINELLA APEXFULVA KAWAIKI, new subspecies

PLATE 3, FIGURE 29; PLATE 12, FIGURES 26, 26a

The shell is similar in form to the elongate shell of *A. a. paalaensis* var. 1 (pl. 12, fig. 22b) but has a lighter gray color pattern and usually tends not to have the yellowish embryonic whorls of figure 22b. The holotype (pl. 3, fig. 29) has the first embryonic whorl and a half white, last embryonic whorl and a half pale cinnamon pink; first half postembryonic whorl pale cinnamon pink axially streaked with light pinkish cinnamon, next two postembryonic whorls pale drab gray axially streaked with light cinnamon drab, last half whorl tinted with wood brown, last whorl with a line of white below the impressed sutural band, and a band of white below the periphery; impressed sutural band pale pinkish buff; lip and columella callus vinaceous buff. Length 19.9 mm., greater diameter 12.2 mm., spire height 11.6 mm., number of whorls $6\frac{3}{8}$.

Distribution, area 99: **Kawaiiki-Kawainui Ridge**, locality 350, elevation 1,550-1,600 feet, 1 dextral; 351, elevation 1,600 feet, 2 dextral 1933; the type lot collected in 1913 from the same ridge was localized from the 1933 material, all Meinecke-collected. Also collected by Wilder, BBM 50506-50507, Thurston, BBM 130892 (figs. 5, 5a, p. 105).

An extreme obese shell (pl. 12, fig. 26) has the embryonic whorls light buff; postembryonic whorls pale drab gray faintly axially streaked with drab gray, last whorl lined above and below the periphery with white; impressed sutural band white; lip and columella callus light pinkish cinnamon. Length 20.1 mm., greater diameter 13.7 mm., spire height 11.1 mm.

The shell may be more conspicuously banded (pl. 12, fig. 26a) and have darker embryonic whorls; embryonic whorls warm buff; last two and a half postembryonic whorls drab gray, axially streaked on the penultimate with light cinnamon drab, last whorl streaked with drab and light drab, last two and a half whorls above the periphery have a band of tilleul buff, below the periphery three bands of tilleul buff; lip and columella callus vinaceous buff. Length 19.0 mm., greater diameter 12.1 mm., spire height 10.8 mm. This form resembles *A. a. paalaensis* var. 1 (pl. 12, fig. 22b).

GROUP OF *A. a.* ALOHA PILSBRY AND COOKE

ACHATINELLA APEXFULVA ALOHA Pilsbry and Cooke

PLATE 2, FIGURE 31; PLATE 12, FIGURES 1-2a

Achatinella apexfulva aloha PILSBRY and COOKE, Man. Conch., vol. 22, p. 330, pl. 60, figs. 15-15a (only), 1914.

To quote from Pilsbry and Cooke:

The shell is dextral, rather small and light, often perforate; white, with *unequal spiral bands of pale cinnamon pink* on the penultimate and last whorls, deepening to brownish vinaceous or orange-cinnamon behind the lip, where they usually become confluent. The *embryonic whorls and a broad band below the suture are white*. Peristome moderately thickened within, light purplish vinaceous, the columellar fold paler.

Length 18.5, diam. 12.7 mm.; $6\frac{1}{2}$ whorls.

Length 19.2, diam. 11.9 mm.; $6\frac{1}{2}$ whorls.

Crest of the division ridge between the two branches of the Kaukinchua [Kaukonahua] stream, above the Waliawa head-gates cabin, the colony extending to within $\frac{3}{4}$ mile of main ridge; on mokihau [mokihana?], pua [*Osmanthus*], maile [*Alyria*], and alani [*Pelea*]. Cotypes in collections A.N.S.P. and Bishop Mus., from No. 3813 Irwin Spalding Coll.

By its cleanly-defined pinkish bands, absence of streaks and white embryo, this snail is well distinguished from other forms of *A. apexfulva*. It is very constant in a large series collected by Mr. Spalding, except for a mutation which occurs in the same colony. This is illustrated in pl. 60, fig. 16, and differs from the normal *A. a. aloha* only by having the bands chocolate-black.

A. a. aloha is always dextral. It is plentiful in a limited locality on one ridge, which is isolated by perennial streams on both sides, and *mauka* (toward the mountains) is shut in by the precipitous side of the main Koolau Range.

Distribution, area 100?: **Kaukonahua**, Wilder, BBM 50561; **North Kaukonahua Stream**, Thurston, BBM 130740. Lectotype BBM (pl. 12, fig. 1). Pilsbry and Cooke plot this locality in the region of area 100?. This locality has not been collected in recent years. Since their information was obtained from Spalding, I believe that the Wilder and Thurston shells can be plotted as coming from the same place because these men either collected together or told each other about their localities so that they could visit them separately (fig. 5a, p. 105).

The usual form and color pattern (pl. 2, fig. 31) on 87 percent of the shells in the Wilder collection has the first postembryonic whorl and penultimate white, penultimate banded just above the edge of the periphery with pale ochraceous salmon, last whorl pale ochraceous salmon with a few faint broken lines of white, sutural and subsutural bands white; lip tinged with pale grayish vinaceous; columella callus white. Length 19.2 mm., greater diameter 13.2 mm., spire height 9.6 mm.

A slightly more obese form (pl. 12, fig. 2) has a similar pattern to plate 2, figure 31 except that it is banded on the last whorl with white like the lectotype. Length 19.2 mm., greater diameter 13.5 mm., spire height 9.5 mm. A narrow specimen (pl. 12, fig. 2a) shows the white form of the shell occurring on 13 percent of the shells; entire shell white, last whorl with lines slightly darker than the ground color; outer margin of the lip ochraceous tawny, remainder of lip and columella callus white. Length 18.9 mm., greater diameter 11.8 mm., spire height 10.0 mm.

ACHATINELLA APEXFULVA ALOHA var. 1

PLATE 2, FIGURE 32; PLATE 12, FIGURES 3, 3a

Achatinella apexfulva aloha PILSBRY and COOKE, Man. Conch., vol. 22, p. 330, pl. 60, fig. 16 (only), 1914.

Area 100?: **Kaukonahua**, Wilder, BBM 50559-50560; **North Kaukonahua Stream**, Thurston, BBM 103741 (fig. 5a, p. 105). This form of *aloha* has an entirely different color pattern from that of typical *aloha* but is found as a rare pattern mixed with typical *aloha*. It is possible that this is a separate race occurring above or below the typical *aloha* area. Future collecting will have to determine this point. Pilsbry considered this variety to be a mutation of *aloha*. (See above description of *A. a. aloha*, p. 160).

The usual form and color pattern (pl. 2, fig. 32) has white embryonic whorls; postembryonic whorls above the periphery white, banded on the last two and a half whorls just above the periphery with claret brown, lined on the last half of the penultimate and the first half of the last whorl below the white subsutural band with a line of clay color, which widens and darkens to a band of claret brown on the last half whorl, below this a line of claret brown on the last whorl, peripheral band on last whorl white, with a central line of claret brown on the last half whorl, base claret brown lined with white within and just without the aperture; impressed sutural band white; lip and columella callus light vinaceous fawn. Length 18.9 mm., greater diameter 13.1 mm., spire height 9.9 mm., number of whorls $6\frac{1}{2}$.

This form may be more heavily banded with claret brown so that the last whorl is almost solid claret brown and lined or banded with white.

The lightest color pattern and elongate form (pl. 12, fig. 3) is a white shell banded just above the edge of the periphery with two bands of claret brown on the last two whorls, on the last whorl a

central line of claret brown, between the two bands, last whorl at and below the periphery white, banded and lined with claret brown; lip and columella callus light vinaceous fawn. Length 20.8 mm., greater diameter 12.8 mm., spire height 11.2 mm.

On 6 percent of the Wilder shells a gray lined color pattern occurs (pl. 12, fig. 3a); embryonic whorls white; postembryonic whorls white faintly banded above the edge of the periphery with a band made up of lines of pale drab gray, which are so faint as to be almost white on the penultimate, on the last half whorl the lines darkening to hair brown and the ground color of the band shaded with pale olive gray, the peripheral band of white shaded or faintly axially streaked with pale olive gray and outlined above by two lines and below by three lines of bone brown which become a single band on the last half of the whorl, base white shaded with pale olive gray and spirally lined with army brown.

ACHATINELLA APEXFULVA ROSEIPICTA, new subspecies

PLATE 3, FIGURE 7; PLATE 12, FIGURES 4-4b

The form of the shell closely resembles that of *A. a. beata*. The color patterns, however, tend toward pastel shades of pink and are closer to those of *A. a. aloha*. The race seems to be intermediate between *A. a. beata* and *A. a. aloha*. The embryonic whorls of the holotype (pl. 3, fig 7) are pale pinkish cinnamon; postembryonic whorls below the white impressed sutural and wide subsutural bands are walnut brown faintly axially streaked or tinted with white and a faint line of burnt umber just below the subsutural band, the ground shading on the last whorl to vinaceous, russet, and kaiser brown on the last half whorl with a faint band of white at the edge of the periphery, which fades out on the last half whorl; lip and columella callus pale grayish vinaceous. Length 19.5 mm., greater diameter 13.0 mm., spire height 10.0 mm., number of whorls 6 $\frac{3}{4}$.

Distribution, area 102: North Kaukonahua-Poamoho Ridge, type locality 286, elevation 1,950 feet, 1933, 1936; also locality 285-3, elevation 1,850 feet, 1933; 285-4, elevation 1,750-1,900 feet, 1936; all collected by Meinecke (figs. 5, 5a, p. 105). Also collected by O. H. Emerson, BBM 103984, on "Spurs north-east of head-gates, Kaukonahua," 1917. The head gates are probably in the North Kaukonahua. Also collected by Wilder, BBM 50563, but the shells have no original label and are marked Poamoho? by C. M. Cooke, Jr., who surmised the locality to be somewhere in that region from the arrangement of this lot in the Wilder collection.

A lighter color pattern (pl. 12, fig. 4) occurs on 37 percent of the shells in area 102; the last two postembryonic whorls and a half pale congo pink faintly lined and banded with vinaceous pink, edge of the periphery of the last whorl banded with a band of white tinted with a very dilute tint of pale congo pink or a dilute pinkish tint of pale vinaceous fawn, base vinaceous pink; subsutural and impressed sutural band white. Length 19.8 mm., greater diameter 12.0 mm., spire height 11.6 mm. Forty-one percent of the shells have the color pattern of the holotype.

Sixteen percent have a pinkish gray or gray color pattern shown by an obese shell (pl. 12, fig. 4a), which has a concave spire, the first two postembryonic whorls white, last whorl and a half below the white sutural and subsutural bands are a very dilute tint of pale grayish vinaceous spirally lined with pale grayish vinaceous, in the umbilical region a patch of honey yellow. Length 19.7 mm., greater diameter 13.8 mm., spire height 9.7 mm.

Six percent have a white color pattern (pl. 12, fig. 4b); which has a spire straight in outline; embryonic whorls pale cinnamon pink shading to white on the first half postembryonic whorl, the remaining whorls white, in the umbilical region a dot or small patch of honey yellow.

ACHATINELLA APEXFULVA ROSEIPICTA var. 1

PLATE 3, FIGURE 8; PLATE 12, FIGURES 5-6

Area 103: **North Kaukonahua-Poamoho Ridge**, locality 289-1a, elevation 2,000-2,050 feet, 1933; 287-1-2, elevation 1,900 feet, 1933; 287-1, elevation 1,900 feet, 8 dextral 1936; 287-2, elevation 1,900 feet, 2 dextral 1936; 287-3, elevation 1,900-1,950 feet, 1936; 288, elevation 1,900-2,068 feet, 1933; all collected by Meinecke (figs. 5, 5a, p. 105).

This variety is intermediate between *A. a. aloha* and *A. a. roseipicta*. The banding resembles *aloha* but the color is much darker and is closer to *roseipicta*. The usual form (pl. 3, fig. 8) and a color pattern, found on 17 percent of the shells, has the embryonic whorls white; postembryonic whorls white, banded and lined with avellaneous, peripheral band white, outlined above and below by bands of cinnamon rufous, base cinnamon rufous, banded with tilleul buff and a band of white; impressed sutural and subsutural bands white; lip and columella callus light vinaceous fawn. Length 19.1 mm., greater diameter 13.0 mm., spire height 9.8 mm., number of whorls $6\frac{1}{4}$.

Eight percent of the shells have a reddish-brown color pattern (pl. 3, fig. 7).

The usual pink-lined color pattern on 67 percent of the shells and the obese form of the shell (pl. 12, fig. 5), has the first two postembryonic whorls tillieul buff below the white sutural and subsutural bands, last whorl vinaceous buff, banded above and at the periphery with white, below the periphery lined with fawn color. Length 19.4 mm., greater diameter 14.0 mm., spire height 9.6 mm. The usual narrow form of the shell (pl. 12, fig. 5a) measures: Length 19.6 mm., greater diameter 12.7 mm., spire height 10.2 mm.; has an extremely light pink lined pattern; postembryonic whorls white faintly lined with a very dilute tint of seashell pink darkening on the last half whorl to buff pink lines or bands.

In locality 287-2 a dark gray color pattern occurs on two specimens. The color pattern (pl. 12, fig. 6) is similar to that of *A. a. poamohoensis* except that the gray ground color is broken up with light lines and bands. The embryonic whorls are pale pinkish buff; postembryonic whorls below the white sutural and subsutural bands pallid mouse gray spirally lined with benzo brown, peripheral band on the first fourth of the last whorl pale smoke gray, last three-fourths whorl bone brown or natal brown, lined and banded with light vinaceous fawn. One shell, or 2 percent, has a white pattern similar to that of plate 12, figure 4b. Another shell from locality 289-1a is black lined and similar to plate 12, figure 3a.

ACHATINELLA APEXFULVA ROSEIPICTA var. 2

PLATE 3, FIGURE 18; PLATE 12, FIGURES 9-12a

Area 105: **Central Poamoho Stream**, locality 280F-1, elevation 1,550 feet, 5 dextral 1933; 280F-2, elevation 1,600 feet, 1933, 1936; 280F-3, elevation 1,600-1,650 feet, 4 dextral 1933, Meinecke; **Poamoho-Helemano Ridge**, 306-4, elevation 1,700-1,950 feet, Welch, 3 dextral 1935; 307-1a-1b, elevation 1,800-1,850 feet, Meinecke, 1917, 5 dextral 1935; 307-1, elevation 1,800-1,850 feet, C. W. Isle, 1 dextral 1935, Welch, 1 dextral 1935; 307-1-2, elevation 1,800-1,965 feet, Meinecke, 5 dextral 1934; 307-3, elevation 1,950 feet, Lemke, 1934; 307-3-308-1, elevation 1,850-1,950 feet, Meinecke, 1934; 308-1, elevation 1,850-1,900 feet, Welch, 2 dextral 1935, Russ, 10 dextral 1931, Russ, BBM 134206, 120037, 1932; 308-2, elevation 1,850-1,900 feet, Welch, 1 dextral 1935, C. W. Isle, 1 dextral 1935; also collected by Lemke above 307-3, BBM 10444, 1934 (figs. 5, 5a, p. 105).

The usual color pattern (pl. 3, fig. 18) is lighter and not so sharply banded as that of typical *beata*. The form resembles *roseipicta* var. 1 in shape and color pattern but differs in shade and range of the color patterns. The race is intermediate between *A. a. roseipicta* and *A. a. beata*. The embryonic whorls are cartridge buff; first two postembryonic whorls white, penultimate whorl banded in the center of the whorl with a band of vinaceous fawn, last whorl below the white sutural and subsutural bands pale vinaceous fawn or a dilute shade of pale vinaceous fawn, banded with vinaceous fawn, in the umbilical region a band of white; lip a faint tint of pale vinaceous fawn, columella callus white. Length 20.0 mm., greater diameter 13.1 mm., spire height 11.1 mm. The usual form is not determined by measurement because of insufficient material. This shell is probably near the usual form.

An obese shell and light color pattern (pl. 12, fig. 9) has white postembryonic whorls banded on the last whorl above the periphery with a band of light vinaceous fawn darkening to vinaceous fawn on the last half whorl, last half whorl below the periphery faintly shaded or lined with a dilute tint of vinaceous fawn. Length 19.8 mm., greater diameter 13.5 mm., spire height 10.0 mm. The shell may have pure white embryonic whorls.

In the higher localities of 307-3 and 308-1 a form (pl. 12, fig. 10) occurs which resembles in color *A. a. aloha* (pl. 12, fig. 2) except that the bands are a darker shade and a different hue. The shell of figure 10 also shows an elongate form; postembryonic whorls white, lined just above the edge of the periphery with two bands of pinkish buff, a very dilute shade on the first whorl and darkening to a stronger shade on the next two whorls, the lower band being pinkish cinnamon on the last whorl, last whorl below the periphery banded or lined with pinkish cinnamon the ground color pale pinkish cinnamon.

A dark color pattern (pl. 12, fig. 11) has a grayish-pink color; first half of the last postembryonic whorl below the white sutural and subsutural bands ecru drab, tinted, faintly lined, and finely axially streaked with light vinaceous fawn, last half whorl cinnamon drab faintly tinted or finely streaked with benzo brown, at the edge of the periphery a band of white, which fades out on the last half whorl.

In locality 308-2 and in other localities at the upper limit of area 106 a gray pattern (pl. 12, fig. 12) occurs which resembles *aloha* var. 1 (pl. 12, fig. 3a), but does not have its obese appearance. The embryonic whorls are pale pinkish buff; postembryonic whorls white, banded

on the last whorl and a half with pale drab gray below the white sutural band, above the white peripheral band banded with hair brown, below the periphery base banded with hair brown and white; lip and columella callus vinaceous fawn.

Lemke found a pink color pattern (pl. 12, fig. 12*a*) which looks like *A. a. roseipicta*, the last whorl and a half vinaceous fawn, finely axially streaked with light vinaceous fawn, on the last whorl at the periphery a band of pale drab gray which fades out on the last fourth whorl, base lined with light vinaceous fawn, a band of white in the umbilical region.

ACHATINELLA APEXFULVA POAMOHENSIS, new subspecies

PLATE 3, FIGURES 5, 6; PLATE 12, FIGURES 7-8

The shell is similar in form to the higher race of *A. a. roseipicta*, but differs in having a gray instead of a pink color pattern. The embryonic whorls of the holotype (pl. 3, fig. 6) are white; post-embryonic whorls white faintly banded on the penultimate with a central band of pale drab gray, last whorl pale drab gray faintly spirally lined with white; lip and columella callus pale vinaceous fawn. Length 19.7 mm., greater diameter 12.8 mm., spire height 9.6 mm., number of whorls 6½.

Distribution, area 101: **North Kaukonahua-Poamoho Ridge**, type locality 284-2, elevation 1,700-1,800 feet; also locality 283-3, elevation 1,750 feet, 5 dextral, 1 sinistral; 283-1, elevation 1,650-1,750 feet, 6 dextral; 283-4, elevation 1,600-1,650 feet, 4 dextral; 284-1, elevation 1,550-1,600 feet, 4 dextral; 285-1, elevation 1,750-1,800 feet, 13 dextral; 285-2, elevation 1,750-1,850 feet, 1 dextral; all collected by Meinecke, 1933 (figs. 5, 5*a*, p. 105).

The usual form of the shell and the dark color pattern (pl. 12, fig. 7) has the embryonic and first postembryonic whorls light buff, penultimate whorl below the white sutural and subsutural bands pale drab gray finely and faintly spirally lined and finely axially streaked with benzo brown, ground of last whorl drab gray, deepening to light drab on the last whorl, finely axially streaked with benzo brown, below the periphery the color shading to saccardo's umber faintly lined with benzo brown, in the umbilical region a patch of cream color; lip and columella callus tilleul buff, outer margin of lip avellaneous. Length 19.3 mm., greater diameter 12.7 mm., spire height 10.8 mm.

The usual yellow pattern and the obese form of the shell (pl. 12, fig. 7*a*) measures: Length 19.1 mm., greater diameter 13.0 mm., spire height 9.5 mm.; embryonic and postembryonic whorls light buff,

spirally banded above the periphery on the first half of the last postembryonic whorl with a faint band of drab gray and a line of cinnamon buff, below the periphery lined with pinkish buff, last half whorl lined, banded, or tinged with pale drab gray; impressed sutural band the color of the ground.

A darker yellow color pattern and elongate shell (pl. 3, fig. 5) has the embryonic whorls pale pinkish buff; postembryonic whorls warm buff, last whorl, below the subsutural band of warm buff, drab gray, and below this, just above the edge of the periphery, a band of warm buff, which fades out on the last half whorl, base drab faintly axially streaked or tinted with warm buff; impressed sutural band pale cinnamon pink; lip and columella callus pale vinaceous fawn. Length 18.7 mm., greater diameter 12.0 mm., spire height 10.4 mm.

An exceedingly dark specimen (pl. 12, fig. 8) is found in locality 283-1; penultimate whorl light drab shading into rood's brown on the last whorl; impressed sutural band pale pinkish buff; subsutural band shading from pale pinkish buff to light buff on the last whorl, on the last half whorl narrowing to a line and fading out.

Below locality 284-2 in area 101 the shells have a yellow ground color, and no shells with white sutural and subsutural bands are present. In locality 284-2 only 6 shells out of 34 have a yellow ground color. In localities 285-1 and 285-2 the impressed sutural and subsutural bands are white, and pinkish gray and white color patterns occur, so that this region appears to be intermediate between *A. a. roscipicta* and *A. a. poamohoensis*.

ACHATINELLA APEXFULVA CERVIXNIVEA Pilsbry and Cooke

PLATE 3, FIGURE 15; PLATE II, FIGURES 8-10

Achatinella apexfulva cervixnivea pattern PILSBRY and COOKE, Man. Conch., vol. 22, pp. 322, 328, pl. 60, figs. 8-8a (only), 1914.

The lectotype of *A. a. cervixnivea* is selected by Pilsbry and myself from the figured cotypes (pl. 60, fig. 8) and reproduced in this paper on plate 11, figure 8. The embryonic whorls are buckthorn brown; postembryonic whorls, below the broad white sutural and subsutural bands, dark quaker drab or deep quaker drab, below the periphery of the last whorl the ground is pale mouse gray, spirally banded, lined, and axially streaked with quaker drab; lip and columella callus light vinaceous fawn. Length 20.0 mm., greater diameter 13.6 mm., spire height 10.0 mm., number of whorls 6 $\frac{1}{4}$.

Distribution, area 93: **Poamoho-Helemano Ridge**, locality 300-4*, elevation 1,500-1,550 feet, Russ, 1932; 300-5, elevation 1,650 feet.

1 sinistral 1933; 300-6, elevation 1,650-1,700 feet, 1917, 6 dextral 1932, 3 sinistral 1934; 300-7, elevation 1,500-1,700 feet, 4 dextral 1934; 300-8, elevation 1,550-1,700 feet, 4 dextral 1933, 1 dextral 1934; 301-1-2*, elevation 1,650 feet, 9 sinistral 1932; 300-6-301-2*, elevation 1,650 feet, 1916, all collected by Meinecke; 300-10, elevation 1,550-1,600 feet, Russ, 4 dextral 1933; 301-1, elevation 1,650 feet, H. B. Baker and Welch, 3 dextral and 6 sinistral 1935; 301-2, elevation 1,650 feet, H. B. Baker and Welch, 1 sinistral 1935. Also collected by Wilder, BBM 50631, 50566 (figs. 5, 5a, p. 105).

The usual form and color pattern (pl. 3, fig. 15) has the embryonic whorls clay color, first fourth postembryonic whorl pale pinkish buff axially streaked or tinged with cinnamon buff, next half whorl pallid quaker drab axially streaked and banded, below the white sutural and subsutural bands, with a band of deep quaker drab, last whorl and a half above the periphery and below the subsutural band vinaceous slate deepening on the last half whorl to dark purple drab, just above the edge of the periphery and all below, ground pale ecru drab finely lined and faintly streaked with deep quaker drab, on the last half of the whorl streaks and lines dark purple drab, in the umbilical region a patch of pale pinkish buff; lip and columella callus light vinaceous fawn. Length 18.8 mm., greater diameter 12.8 mm., spire height 9.8 mm., number of whorls 6.

A light color pattern (pl. 11, fig. 9), has the last two postembryonic whorls, below the white sutural and subsutural bands, pale vinaceous fawn shading to light vinaceous fawn on the last half whorl, spirally banded and faintly axially streaked with ecru drab, on the last half whorl bands and streaks brownish drab, in the umbilical region a band of pale pinkish buff.

The usual form of a sinistral shell (pl. 11, fig. 9a) has a color pattern similar to that of plate 3, figure 15, except that the embryonic whorls in this specimen are warm buff. Length 18.7 mm., greater diameter 12.0 mm., spire height 10.0 mm.

In locality 300-4 the usual pattern has a more pinkish ground than the typical pattern. Among these pinkish gray shells two extremely light pink forms are found. One of these (pl. 11, fig. 10) shows an obese shell; postembryonic whorls with a band of pecan brown below the white sutural and subsutural bands, below which the ground is buff pink streaked and lined on the last whorl with pecan brown; lip and columella callus pale vinaceous pink. Length 19.3 mm., greater diameter 13.6 mm., spire height 10.2 mm.

From the data on hand *cervixnivea* runs from pinkish forms at a low elevation to dominantly light gray shells. At the upper end of

area 93 near area 94 *beata*-like forms and the black forms of *beata* var. I are found mixed with *A. a. cervinivca*.

ACHATINELLA APEXFULVA BEATA Pilsbry and Cooke

PLATE 3, FIGURE 17; PLATE 12, FIGURES 13-16

Achatinella apexfulva beata PILSBRY and COOKE, Man. Conch., vol. 22, p. 329, pl. 60, figs. 17a-17c; pl. 55, fig. 5 (only), 1914.

Achatinella apicata var. *alba* SYKES, Fauna Hawaiiensis, p. 299, 1900. Not *Achatinella alba* Nuttall in Jay's Catalogue, ed. 3, p. 58, 1839 (name only), which is *Achatinella lorata* Férussac.

Achatinella apexfulva alba SYKES, Pilsbry and Cooke, Man. Conch., vol. 22, p. 324, 1914.

The shell of Pilsbry's plate 60, figure 17a, reproduced here on plate 12, figure 13, is considered the lectotype. The embryonic whorls are cream color; postembryonic whorls, below the white sutural and subsutural bands, with a band of liver brown, below which is a band of white or seashell pink, last whorl below the white sutural and subsutural bands seashell pink, banded above, at the edge and below the periphery with livid brown, below the periphery the bands faintly axially streaked with seashell pink, in the umbilical region a patch of naples yellow; lip pale vinaceous fawn, columella callus white. Length 19.8 mm., greater diameter 13.0 mm., spire height 11.0 mm., number of whorls 6 $\frac{5}{8}$. The pattern is dominantly a banded one, and the streaks are faint or not prominent.

Distribution, area 104: **Central Poamoho-Central Poamoho North Branch Ridge**, locality 280L-6, elevation 1,850-1,950 feet, Meinecke, 1933; 280L-7, elevation 1,900 feet, Meinecke, 3 dextral 1933; 280L-9, elevation 1,850 feet, Russ, 1934; **Poamoho-Helemano Ridge**, locality 303, elevation 1,700-1,800 feet, Meinecke, 1934, Russ 1934; 304, elevation 1,800-1,900 feet, Meinecke, 1 dextral 1933, 1 dextral 1934, Welch, 1935; 305, elevation 1,850-2,300 feet, Meinecke, 2 dextral 1933, Welch, 4 dextral 1935; 306-1, elevation 1,850-2,000 feet, Meinecke, 7 dextral 1933; 306-3, elevation 1,750-1,850 feet, 1 sinistral 1934; also 302-304?, BBM 122106, 1916; 305-306-2?, BBM 122112-122113, 1932, less localized Meinecke material plotted from memory; **South Helemano Stream**, locality 300H, elevation 1,500-1,600 feet, Meinecke, 1 dextral 1934; 300G, elevation 1,600-1,750 feet, Meinecke, 6 dextral 1934; **North-South Helemano Ridge**, locality 317, elevation 1,750-1,950 feet, Meinecke, 8 dextral 1934. Other collectors of *A. a. beata* probably from area 104 are Thurston, BBM 130772, Wilder, BBM 50633, Lemke, and others (figs. 5, 5a, p. 105).

The usual form and color pattern (pl. 3, fig. 17) has the embryonic whorls warm buff; first half postembryonic whorl warm buff, last half white with a central band of clay color, last two whorls above the periphery white with a central band of hazel shading into kaiser brown on the last whorl, last whorl below the kaiser brown peripheral band Naples yellow banded with kaiser brown; lip pale vinaceous fawn, columella callus white. Length 19.8 mm., greater diameter 12.8 mm., spire height 10.3 mm.

The lightest color pattern and obese form (pl. 12, fig. 15) has the embryonic whorls light buff; postembryonic whorls white, last whorl above the periphery banded with light pinkish cinnamon, below the edge of the periphery pale pinkish buff faintly banded on the last half whorl at the edge of the periphery and about the base with light vinaceous fawn; lip and columella callus light grayish vinaceous. Length 19.3 mm., greater diameter 13.6 mm., spire height 9.1 mm.

The dark banded color pattern and narrow form (pl. 12, fig. 14) has the first two postembryonic whorls white, banded about the middle of the whorl above the periphery with a band darkening from light pinkish cinnamon on the first postembryonic whorl to pecan brown on the penultimate and last whorl; sutural and subsutural bands white, on the last whorl the white supraperipheral band is shaded with seashell pink, the peripheral band is walnut brown deepening to burnt umber on the last half of the whorl, subperipheral band light vinaceous cinnamon fading out on the last half whorl, remainder of base, except for a patch of pale pinkish buff in the umbilical region, burnt umber faintly lined and axially streaked with light vinaceous cinnamon. Length 20.0 mm., greater diameter 12.3 mm., spire height 11.2 mm.

The color pattern (pl. 12, fig. 16) is similar to plate 3, figure 17, except that the embryonic whorls have a more snow-white ground, and the last whorl below the periphery is massicot yellow faintly banded and axially streaked with fawn color, last fourth whorl streaked with army brown.

The holotype of *A. a. alba* Sykes in the British Museum is a white shell similar to the white color forms of *A. a. beata* and which was collected by Perkins in Kawaihoa. *A. a. beata* would have to be put in the synonymy of *A. alba* if the name *alba* were not already pre-occupied. The name *alba* was used by Nuttall, in Jay's Catalogue, and placed in the synonymy of *A. pallida* Nuttall by Reeve (Conch. Icon., vol. 6, pl. 1, species 2, 1850). No white shells similar to *A. a. beata* have been taken in Kawaihoa proper. Mr. Sykes' shell may have

come from the Helemano-Opaaula Ridge, which is the division ridge between the districts of Paala and Kawaihoa. This ridge is the most northern ridge known to contain white *beata*-like shells.

ACHATINELLA APEXFULVA BEATA var. 1

PLATE 3, FIGURE 16; PLATE II, FIGURES 11-13

Achatinella apexfulva beata PILSBRY and COOKE, Man. Conch., vol. 22, p. 329, pl. 60, fig. 17 (only), 1914.

Area 94: **Poamoho-Helemano Ridge**, locality 302, elevation 1,750 feet, Meinecke, 1916, 1932, Russ, 2 dextral 1933; 302-291-5, elevation 1,750-1,802 feet, Baker and Welch, 2 dextral 1935; **North-Central Poamoho Ridge**, locality 291-3-5*, elevation 1,650-1,802 feet, 1916-1917, 1932; 291-5, elevation 1,750-1,802 feet, 4 dextral 1934, all Meinecke localities. Also collected by Wilder, BBM 50568-50569, and others.

Area 94-94a?: **North-Central Poamoho Ridge**, locality 291-2?, elevation 1,600-1,700 feet, 6 dextral 1932; 291-3?, elevation 1,650-1,700 feet, 12 dextral 1926; 291-2-302?, elevation 1,600-1,800 feet, 1914, all Meinecke-collected. The shells in this area contain a mixture of color patterns of typical *A. a. cervixnivea* and *beata* var. 1. All the localities are plotted from memory and are of wide extent. Probably if more localized collecting were done in area 94a, the lower portion of the ridge might contain only *cervixnivea* while the upper portion of area 94 might contain a dominance of the dark color pattern of *beata* var. 1 (figs. 5, 5a, p. 105).

Pilsbry also considered this race a form of *beata*; actually it is a distinct race existing between *beata* and *cervixnivea* with a color pattern distinct from both. However, this form is so close to the typical *apexfulva* that it is almost impossible to tell the difference between the forms. Typical *apexfulva* usually has forms with the last whorl a light yellowish color and banded, lined, and axially streaked with chocolate or black, while *cervixnivea* var. 1 usually has a solid color or patterns intermediate with typical *cervixnivea* or *beata*.

The usual form (pl. 3, fig. 16) from locality 291-3-5 measures: Length 19.4 mm., greater diameter 13.4 mm., spire height 10.3 mm.; the color pattern is a little lighter than usual; embryonic whorls light buff; last two and a half postembryonic whorls chocolate, tinted or lightened with streaks of mahogany red; impressed sutural band warm buff, shaded on the lower half of the band on the last whorl with russet; lip and columella callus white.

A more usual color pattern and the usual form in the Wilder collection (pl. 11, fig. 12) has the last two whorls maroon; impressed sutural band mahogany red, the upper portion of which is lined or edged with pale pinkish buff; lip and columella callus pale vinaceous fawn. Length 19.7 mm., greater diameter 12.8 mm., spire height 10.8 mm. In a lot of 69 shells, 11 percent have white sutural bands similar to those of plate 11, figure 11. The postembryonic whorls on this specimen are particularly dark, being seal brown.

One or two specimens in area 94 have a yellowish color pattern (pl. 11, fig. 13), the embryonic whorls warm buff; first half post-embryonic whorl warm buff lightly axially streaked with ochraceous tawny, on the penultimate and last whorl above the periphery, the upper third of the whorl, including the impressed sutural and sub-sutural bands, amber brown faintly axially streaked with pale orange yellow, below which the middle third of the whorl has a band of dusky brown which is faint on the early whorls and does not really start until the second half of the penultimate, just above the edge of the periphery a band of pale orange yellow, tinted with amber brown, which becomes narrower on the last half of the whorl, below the periphery dusky brown faintly tinted or streaked with pale orange yellow, in the umbilical region a band of mars yellow.

ACHATINELLA APEXFULVA BEATA var. 2

PLATE 3, FIGURE 22; PLATE 12, FIGURES 17, 18

Area 108: **North-South Helemano Ridge**, locality 318, elevation 1,800-1,900 feet, 1934; 318a, elevation 1,850-1,950 feet, 1934; 319, elevation 1,850-1,900 feet, 5 dextral 1934; 319a, elevation 1,950-2,000 feet, Meinecke, 1 dextral 1934 (figs. 5, 5a, p. 105).

In area 108 the shells are dominantly white color forms mixed with *beata* color patterns. The usual form of the shell (pl. 3, fig. 22) has the embryonic whorls a dilute shade of light buff; remainder of the shell white except for about 3.5 mm. behind the edge of the lip, where the ground is tinged with naples yellow; lip and columella callus white. Length 19.4 mm., greater diameter 12.7 mm., spire height 11.0 mm.

An extremely obese shell (pl. 12, fig. 17) is pure white; the embryonic whorls are worn and lack the shell nacre; the lip and columella callus white, outer margin of the lip clay color. Length 19.2 mm., greater diameter 13.5 mm., spire height 9.8 mm. A narrow shell (pl. 12, fig. 18) shows the usual light *beata* pattern; postembryonic whorls white, last postembryonic whorl above the periphery with a

band of buff pink deepening to cacao brown on the last half of the whorl, last whorl below the periphery white on the first half of the whorl, last half banded at the edge of the periphery and on the base with cacao brown, subperipheral band white tinged with vinaceous pink. Length 19.7 mm., greater diameter 12.7 mm., spire height 11.2.

ACHATINELLA APEXFULVA BEATA var. 3

PLATE 3, FIGURE 25; PLATE 12, FIGURE 19-19b

Area 110: **Helemano-Opaewa Ridge**, locality 337-4, elevation 1,900-2,000 feet, 1934; 338, elevation 1,950-2,000 feet, Meinecke, 1934; also less localized Meinecke material plotted from memory, locality 338-339-1?, BBM 128329-128333, 122335-122336, 1929; 339-1a*, elevation 1,950-2,000 feet, 1929; 338?, BBM 122267, 1928 (figs. 5, 5a, p. 105).

This race differs from *A. a. beata* in usually having lighter pink color patterns and a different range of color patterns. The characteristic pattern of this area (pl. 3, fig. 25) has the embryonic whorls cream buff; first two postembryonic whorls white, first half of the last whorl white faintly shaded with a very dilute color of pale grayish vinaceous, lightly banded with light russet vinaceous, last half whorl vinaceous brown, faintly lined or banded and axially streaked with light russet vinaceous and banded with white in the umbilical region; lip and columella callus light grayish vinaceous. Length 19.6 mm., greater diameter 13.5 mm., spire height 10.3 mm. The aboral surface of this shell is figured in order to show the abrupt change of coloration from white to a dark almost solid pinkish color on the last half whorl. This pattern is found only in area 110.

A darker pattern (pl. 12, fig. 19) has the first half of last whorl light brownish vinaceous, banded and shaded with russet vinaceous, last half whorl almost solid vinaceous brown faintly lined and streaked with a lighter tint.

A white specimen (pl. 12, fig. 19a) lacks color except for the cream-buff embryonic whorls and a line of ochraceous tawny on the outer margin or back edge of the lip. Plate 12, figure 19b, shows a rare pink color form with the postembryonic whorls a very dilute tint of pale flesh color deepening to flesh color on the last whorl, 3.5 mm. behind the edge of the lip the color deepening to vinaceous pink.

ACHATINELLA APEXFULVA VESPERTINA Baldwin

PLATE 3, FIGURE 28; PLATE 12, FIGURES 23-25

Achatinella vespertina BALDWIN, Proc. Acad. Nat. Sci., Philadelphia, 1895, p. 219, pl. 10, fig. 14.—PILSBRY and COOKE, Man. Conch., vol. 22, p. 322, pl. 60, figs. 2, 3, 1914.

The holotype in the Academy of Natural Sciences (pl. 12, fig. 23) has the embryonic whorls cartridge buff shading to light pinkish cinnamon on the last half embryonic whorl; postembryonic whorls light pinkish cinnamon; impressed sutural band cartridge buff; lip and columella callus cartridge buff. Length 20.6 mm., greater diameter 14.3 mm., number of whorls 6 $\frac{3}{4}$.

Distribution, area 98?: **Kawailoa**, D. D. Baldwin, type lot, BBM 57996, 5 dextral, also BBM 54685, 54737, 6 dextral, E. Lyman ex Baldwin, BBM 167354, 9 dextral; **Kamoku**, J. S. Emerson, BBM 102310-102311; **Waialua**, J. S. Emerson, BBM 102309; "Kawaiiki $\frac{1}{2}$ way down the valley, side north of 2nd Kamoku Plateau." (O. P. Emerson label in O. H. Emerson collection, BBM 103983.) "In a secondary ravine of Kawaiiki Valley on the South side, not quite as far up the valley as the hut back of Kamoku." (O. P. Emerson label in MCZ.) Also collected by Wilder, BBM 50605, and Spalding in **Kawaiiki Gulch**. The Wilder lot has no label but is localized from the Spalding collection. Spalding collected with Wilder, and on his authority the approximate area 98? is marked on fig. 5a, page 105.

The usual form and color pattern of the shell (pl. 3, fig. 28) has been selected from the Baldwin and Lyman lots. The embryonic whorls are light buff; postembryonic whorls pale ochraceous salmon with a faint band on the last two whorls just above the edge of the periphery of pale cinnamon pink, on the last whorl, below this band, is a line of the same color; impressed sutural band the ground color; lip and columella callus pale ochraceous salmon. Length 19.6 mm., greater diameter 13.1 mm., spire height 10.8 mm.

In a lot in the Wilder collection the usual form (pl. 12, fig. 24) has a more obese appearance, and also shows a pinkish-hued form which does not occur in the type lots; embryonic whorls pale pinkish buff; first postembryonic whorl and a half pale pinkish buff faintly streaked with pinkish buff, last postembryonic whorl and a half vinaceous pink spirally banded and lined with pale vinaceous fawn; impressed sutural band pale pinkish cinnamon; lip and columella callus white or a dilute tint of tilleul buff. Length 19.1 mm., greater diameter 13.4 mm., spire height 10.5 mm.

A narrow shell (pl. 12, fig. 25) measures: Length 19.5 mm., greater diameter 11.6 mm., spire height 11.5 mm.; embryonic whorls white; first two postembryonic whorls a dilute tint of tilleul buff, last whorl a very dilute tint of seashell pink spirally banded and lined above and below the wide peripheral band with seashell pink.

ACHATINELLA APEXFULVA KAHUKUENSIS Pilsbry and Cooke

PLATE 3, FIGURE 34; PLATE II, FIGURES 32-33a

Achatinella valida kahukuensis PILSBRY and COOKE, Man. Conch., vol. 22, p. 338, pl. 52, figs. 17-17a, 1914.

To quote from Pilsbry and Cooke:

The shell is dextral, white above, yellow below the periphery, usually encircled with a black-brown line at the junction of the two ground-tints, and often there are several additional lines widely spaced on the base or sometimes above. A faint sutural line may usually be discerned. Embryonic whorls when unworn are cartridge buff, slightly darker near the sutures, but not at the tip. The outlines of the spire are perceptibly concave, the last whorl swollen. Lip moderately thickened, white; columella very faintly rose-purple.

Length 20, diam. 13 mm.; 6½ whorls.

Length 18.7, diam. 12.2 mm.; 6½ whorls.

Oahu: Kahuku, at an elevation of 1,500 to 1,750 ft. (L. A. Thurston). Co-types in collection A. N. S. and Bishop Mus., from Mr. Thurston's Collection.

Distribution, area 115?: **Malaekahana-Laie Ridge**, Thurston BBM 130973. From Thurston's description of the locality, the ridge is undoubtedly the **Malaekahana-Kaluakauila Ridge**. The exact location is not known but tentatively may be placed in area 115?. (fig. 6a, p. 185). Also collected by Wilder, BBM 50608, J. S. Emerson, BBM 102339.

The shell of Pilsbry's plate 52, figure 17, is here reproduced on plate 11, figure 32, and is considered the lectotype because it has the usual color pattern of the shell. The color pattern of the lectotype is similar to that of plate 3, figure 34, which is an obese form of the shell, and has the first two and a half embryonic whorls worn and cream color, last embryonic whorl white; postembryonic whorls above the periphery white, last whorl, below the peripheral band of burnt umber, honey yellow with two central lines of cinnamon; outer margin of the lip avellaneous, inner margin white, columella callus light vinaceous fawn. Length 19.4 mm., greater diameter 13.5 mm., spire height 10.5 mm.

A lighter color pattern (pl. 11, fig. 33) has the embryonic whorls light buff; postembryonic whorls white, shaded or faintly banded with pale mouse gray, on the penultimate whorl a band of cinnamon on the upper third of the whorl fading out on the last whorl, last

whorl banded at the periphery with a band of amber brown, below the periphery the first half of the last whorl chamois shading to white on the last half of the whorl, entire whorl lined with natal brown, the last half of the whorl more profusely lined and banded than the first half; impressed sutural band wood brown; lip and columella callus light vinaceous buff.

One shell in the Thurston lot (pl. 11, fig. 33a) has the post-embryonic whorls white, banded just above or at the edge of the periphery with natal brown, on the last whorl the band or line fades to army brown and on the last half of the whorl to a line of cinnamon, within and just outside the aperture the shell callus honey yellow; impressed sutural band white. Length 20.3 mm., greater diameter 13.3 mm., spire height 10.8 mm.

A narrow shell measures: Length 18.0 mm., greater diameter 11.5 mm., spire height 10.3 mm.

GROUP OF A. A. APEXFULVA DIXON

ACHATINELLA APEXFULVA APEXFULVA Dixon

PLATE 3, FIGURE 27; PLATE 11, FIGURES 17-19

Helix Apex Fulva DIXON, A voyage round the world; but more particularly to the north-west coast of America, p. 354, *Turbo Apex Fulva* Dixon, on unnumbered plate, 1789.

Achatinella apexfulva DIXON, Pilsbry and Cooke, Man. Conch., vol. 22, 317, pl. 50, fig. 15; pl. 60, figs. 1-1b (only), 1914.

Turbo lugubris, etc., CHEMNITZ, Neues Syst. Conch. Cabinet, vol. 11, p. 278, pl. 209, figs. 2059-2060, 1795.

Helix lugubris CHEMNITZ, Férussac, Tabl. Syst., Fam. Limaçons, p. 56, 1821 (not *Helix lugubris* Gmelin, Syst. Nat., vol. 13, p. 3665, 1791).—FÉRUSAC, in Freycinet's Voyage autour du Monde de l'Uranie et la Physicienne, Zoologie, p. 479, 1824.—VON MARTENS, Malakozool. Blätt., vol. 19, p. 40, 1872.

Achatinella lugubris CHEMNITZ, Pfeiffer, Monographia Heliceorum Viventurum, vol. 2, p. 239, 1848; vol. 3, p. 465, 1853; vol. 4 p. 542, 1859; vol. 6, p. 177, 1868.—REEVE, Conch. Icon., vol. 6, *Achatinella*, pl. 2, fig. 10a (not 10b), April 1850.

Monodonta seminigra LAMARK, Hist. Nat. Anim. sans Vert., vol. 7, p. 37, 1822; 2d ed., Deshayes and Edwards, vol. 9, p. 181, 1845.—DELESSERT, Recueil de Coq., Decrites par Lamark, pl. 37, figs. 2a-c, 1841.

Bulinus seminiger MENKE, Synops. Method. Moll., 2d ed., p. 26, 1830.

Achatinella pica SWAINSON, Quart. Journ. Sci., Lit., and Art, January-March, p. 84, 1828; Zool. Illustr., ser. 2, vol. 3, p. 99, pl. 99, fig. 1, 1832-1833.

To quote from Dixon:

. . . . the natives form necklaces, bracelets, and other ornaments: one of these necklaces afforded a singular species of the *Helix* genus of Linnaeus, which I was informed is a fresh-water shell. It is outwardly smooth, has seven spires,

and is of a black-brown colour, except the tip, which is pale-yellow: the inside is smooth and white, and the mouth is marginated within. It is remarkable for a knob or tooth on the columella, but which does not wind round it, consequently excludes it from the *Voluta* genus of Linnaeus, to which at first sight it appears to be related. As I presume it to be a species hitherto undescribed, I have taken the liberty to give it the trivial name of *Apex Fulva*, or the *Yellow Tip*. A figure of it, in two views, is given in one of the following plates.

Specimens of this kind are in the Leverian Museum.

Distribution, area 97: "Picked before 1861 in Opaëula Valley on the south side opposite ridge running down over the tunnel. Picked on iëie [*Freycinetia*], kawau [keawau=*Ilex*], kopiko [*Straussia*], kolea [koolea=*Myrsine*]." (O. P. Emerson label for his lot of *A. a. apexfulva* in MCZ.) "Opaëula Gulch, Waialua," J. S. Emerson, BBM 102270, 102272; Kamoku, J. S. Emerson, BBM 33298; Opaëula Gulch, locality 330-4, elevation 1,100 feet, Welch, K. Emory, and W. Giffard, 15 dead dextral 1935. This locality is on the south side of the Gulch and answers O. P. Emerson's description of his locality, and is probably the place where the Emerson brothers got their material (see figs. 5, 5a, p. 105).

According to Murray (1904, p. 175) the Leverian Museum was formed by Sir Ashton Lever (1729-1788) in the early years of his life at his house, Alkington Hall, near Manchester. In 1783 the museum was sold by lottery. The lottery was won by James Parkinson. In 1806 the museum was sold at auction. In a copy of the sales catalog of the Leverian Museum, in my possession, there are 10 lots which mention necklaces, bracelets, and other ornaments, made of shells, from the Sandwich Islands. One of these ornaments may be the one Dixon refers to, which contains the type or paratypes of *A. a. apexfulva*. The lei (necklace) Dixon studied may have been broken up and the specimens sold. Dixon's original figure is reproduced on plate 11, figure 17.

Pilsbry and Cooke (1914, p. 321) give such a good account of the history of *A. a. apexfulva* that it seems unnecessary to review the matter again. In discussing the origin of shell leis Pilsbry says:

It appears that shell leis were strung by the natives of the good agricultural region about Waialua Bay, who doubtless got the shells from the lower forests in the back country, in various places in Kawailoa and Helemano districts. They were carried or traded eastward, and so obtained by explorers harboring at Honolulu. It is altogether likely that all of the *A. apexfulva* of these leis were from some one colony in Opaëula Gulch.

Pilsbry correctly considers *Turbo lugubris*, *Monodonta seminigera*, and *A. pica* synonyms of *A. a. apexfulva*. The types of these forms

are not available to me and may be lost. It is possible that *lugubris* and *seminigera* come from the same lei Dixon used. If the shells came from another lei there is a possibility that the shells are different from *apexfulva*. But until the types are seen it is impossible to say what the shells really are, and Pilsbry's identification should stand. Swainson's shells were collected by Captain Byron of H. M. S. *Blond*. These again could have come from elsewhere than the type locality of *apexfulva*. Again until the type is studied it is difficult to say whether the shell is or is not *A. apexfulva*. The Swainson shells may be forms from area 94 of *A. a. beata* var. 1, which are impossible to separate from typical *A. a. apexfulva*. Therefore, even were the types available for all three forms they might be from different localities and yet not separable from *A. a. apexfulva*, so that it is best to consider them synonyms.

Since the holotype of *A. a. apexfulva* has not been located, the shells in the J. S. Emerson lot in the Bishop Museum, the Academy of Natural Sciences, and the O. P. Emerson lot in the Museum of Comparative Zoology will be considered typical. The usual form and color pattern in the J. S. Emerson lot (pl. 3, fig. 27) has the embryonic whorls light buff; postembryonic whorls hessian brown or maroon; impressed sutural band the color of the ground with the upper extreme edge pale pinkish buff; lip and columella callus pale vinaceous fawn. Length 18.8 mm., greater diameter 12.3 mm., spire height 10.8 mm., number of whorls $6\frac{1}{2}$.

An extreme obese form (pl. 11, fig. 18) measures: Length 18.8 mm., greater diameter 13.3 mm., spire height 10.2 mm.; the color pattern is similar to figure 27 except that the last whorl is faintly streaked with tawny. Eight specimens in the Emerson lot of 38 specimens have a gray streaked pattern similar to plate 11, figure 18a; last two postembryonic whorls maroon, streaked with pale quaker drab, the streaks cut by lines of maroon. Length 19.1 mm., greater diameter 12.3 mm., spire height 11.0. Pilsbry's plate 60, figure 1c, does not look like *A. a. apexfulva*, but rather like the lined form, or *A. a. aloha* var. 1. No such color pattern is found in the J. S. Emerson lots from Opaëula. The shell may be a rare color pattern of an intermediate race which occurred between *A. a. apexfulva* and *A. a. duplocincta*. Then again it may be a stray shell that was mixed in with the shells of *A. a. apexfulva*.

An adult shell from locality 330-4 is shown on plate 11, figure 19.

ACHATINELLA APEXFULVA DUPLOCINCTA Pilsbry and Cooke

PLATE 3, FIGURE 26; PLATE 12, FIGURES 27, 28

Achatinella apexfulva color form *duplocincta* PILSBRY and COOKE, Man. Conch., vol. 22, p. 323, pl. 55, figs. 6-8, 1914.

To quote from Pilsbry and Cooke:

The shell is dextral, white, encircled with two chestnut bands or group of lines, one at the periphery, the other below it; lip faintly violaceous. Length 18, diam. 11 mm. Length 17, diam. 11.7 mm.

The cotypes of this form are 1272, 1273 Cooke coll., 108776 A. N. S., and 1213 Gulick coll., Boston Soc. The former lots are labelled "Wahiawa, Emerson, extinct?", three banded specimens, one drawn in fig. 8, and two in which the bands are very faint, a little stronger near the lip. The locality seems open to doubt. The Gulick lot is from "Kawailoa, east side."

Distribution, area 97A??: Type locality **Kawailoa, Waialua**, "on a group of 3 or 4 trees at the head of a little gulch beside and to the north of the road to Kamoku, some two miles makai [toward the sea] of Kamoku, collected by J. S. Emerson previous to the year 1863." (J. S. Emerson label, BBM 102312.) The original label on the O. P. Emerson shells in the Museum of Comparative Zoology reads: "Picked before 1861 in a secondary ravine branching S. from the Kamoku reservoir valley below the narrows which is now a grassy hollow. An old Akakea tree [*Bobea* sp.?] bore the shells—all now extinct—and not found elsewhere by me." The shell of Pilsbry and Cooke's plate 55, figure 8, here reproduced on plate 12, figure 27, is selected for the lectotype. The label Wahiawa on the Cooke type lot is surely erroneous, because the shells came from J. S. Emerson who obtained his specimens from Kawailoa. From the above data of the Emerson brothers, *A. a. duplocincta* was a lowland race that occurred below the colony of *A. a. apexfulva*, which probably occurred in Opaaula Gulch area 97 and was somewhere along the road on the top of the Opaaula-Kawailoa Ridge. Area 97A?? is the probable region of the type locality (fig. 7, p. 194).

The usual form and color pattern in the type lot in the J. S. Emerson collection (pl. 3, fig. 26) is a white shell, with a single line of cinnamon above the periphery on the last whorl, and four lines of mikado brown below the periphery; lip and columella callus light pinkish cinnamon. Length 17.9 mm., greater diameter 11.8 mm., spire height 10.0 mm., number of whorls 6½.

A narrow specimen and darkest color form (pl. 12, fig. 28) is a white shell banded just above the periphery on the last two whorls with two bands of mikado brown, above which on the last whorl and

a half are three faint lines of cinnamon, base banded with four bands of burnt umber. Length 17.3 mm., greater diameter 10.7 mm., spire height 9.6 mm. An obese shell measures: Length 17.1 mm., greater diameter 12.6 mm., spire height 9.2 mm.

ACHATINELLA APEXFULVA BAKERI, new subspecies

PLATE 3, FIGURE 30; PLATE 11, FIGURES 20-20b

The shell is small, the last whorl is usually yellow, and has a characteristic yellow subperipheral band. The form is extinct today. It probably came from an isolated lowland locality. No intermediates have been located by me connecting it to any other race of *A. apexfulva*. The strongly axially streaked color pattern is similar to *A. a. apicata* or *A. a. wahiawa*. The presence of the subperipheral band may cause this form to be confused with *A. a. gulickii*. But *A. a. bakeri* mainly differs from both forms in the yellow color pattern of the last whorl.

The embryonic whorls of the holotype (pl. 3, fig. 30) are light ochraceous buff; first half postembryonic whorl vinaceous fawn axially streaked with white, next half whorl pale drab gray axially streaked with light brownish drab, last whorl and a half Naples yellow axially streaked with straight and zigzag streaks, speckled and lined with Mars brown, below the edge of the periphery a band of Naples yellow; impressed sutural band pale pinkish buff; lip and columella callus tile buff. Length 16.4 mm., greater diameter 11.5 mm., spire height 8.5 mm. The usual form was not determined because of the paucity of specimens.

Distribution, area?: Waimea, J. S. Emerson, BBM 102333, A. F. Judd ex J. S. Emerson, BBM 162334. "Found on a Plateau north of Waihalona [Kawaihalona?] Gulch below North Branch on pua [*Osmanthus*] tree on a clump in open plain." (O. P. Emerson collection, MCZ.) This form is named after Dr. H. B. Baker, of the University of Pennsylvania.

The shell may be narrower (pl. 11, fig. 20) and have a vivid yellow ground; the first postembryonic whorl brownish drab axially streaked with white or pale drab gray, last two whorls yellow ochre axially streaked with natal brown, just below the edge of the periphery a band of yellow ochre. Length 18.2 mm., greater diameter 11.5 mm., spire height 10.5 mm.

A lighter color pattern and an obese shell (pl. 11, fig. 20a) has the first half postembryonic whorl axially streaked with light cinnamon drab and white, penultimate whorl pale pinkish cinnamon or white,

streaked with light brownish drab, last whorl cream buff lightly streaked with straight and zigzag streaks of verona brown, about the periphery and base, bands of cream buff. Length 17.5 mm., greater diameter 11.8 mm., spire height 8.7 mm.

The last whorl may not have a wide yellow peripheral band (pl. 11, fig. 20*b*); first postembryonic whorl axially streaked with brownish drab or deep brownish drab and pallid mouse gray, penultimate whorl streaked with deep quaker drab and pallid mouse gray, last whorl pale pinkish buff shaded with cream buff axially streaked with sepia and warm sepia. Length 17.3 mm., greater diameter 11.0 mm., spire height 9.3 mm.

ACHATINELLA APEXFULVA LEUCOZONA Gulick

PLATE 3, FIGURE 31; PLATE 11, FIGURES 28-31

Apex leucozonus GULICK, Proc. Zool. Soc. London, 1873, p. 83, pl. 10, fig. 6.
Achatinella valida cinerosa PFEIFFER, Pilsbry and Cooke, Man. Conch., vol. 22, pp. 337, 338, pl. 55, figs. 9-16, 1914.

The embryonic whorls of the holotype (pl. 11, fig. 29) are cartridge buff, last half embryonic whorl banded on the lower fourth of the whorl with a band of a light tint of isabella color; postembryonic whorls pale drab gray, first two postembryonic whorls axially streaked with benzo brown and lined with drab, last whorl banded and axially streaked with snuff brown darkening to verona brown on the last half whorl. Length 18.2 mm., greater diameter 12.7 mm.

Distribution, area?: Type locality **Waialei** [**Waialea**], Gulick, BBM, ANSP 92656; **Waialea**, J. S. Emerson, BBM 102337. Holotype, MCZ 39906.

A. a. leucozona is either a highland or a lowland form of *A. a. napus*. The shell of plate 11, figure 28, looks like an intermediate form between *A. a. napus* and *A. a. leucozona* but closest to the color pattern of *A. a. leucozona*. The embryonic whorls are light buff; first postembryonic whorl light buff, streaked with mikado brown, penultimate whorl a yellowish tint of avellaneous streaked with wood brown, and lined and banded with pinkish buff, last whorl above the periphery banded and lined with pinkish buff and a narrow and a wide band of buckthorn brown, at the edge of the periphery a band of light buff, and a subperipheral band of raw sienna, base raw sienna banded with a wide band of a light tint of antique brown axially streaked with antique brown, below which is a line of argus brown.

The usual form of the shell (pl. 3, fig. 31) in the Gulick ANSP lot has the embryonic whorls white; first two postembryonic whorls

light drab faintly spirally lined with white and strongly axially streaked with cinnamon drab, last whorl wood brown axially streaked with straight and zigzag streaks of wood brown, fawn color, and light pinkish buff, and faintly spirally lined with white and wood brown, just below the edge of the periphery a line of white; impressed sutural and subsutural bands white; lip pale ochraceous buff, columella callus white. Length 17.7 mm., greater diameter 11.4 mm., spire height 9.9 mm.

The lightest color pattern and obese form of the shell (pl. 11, fig. 30) has the first postembryonic whorl pale drab gray, banded and streaked with light cinnamon drab, penultimate whorl pale ecru drab banded and streaked with ecru drab, first half of the last whorl a light tint of pale ecru drab, lined and streaked with ecru drab, last half whorl pale vinaceous fawn, lined and faintly streaked with light vinaceous fawn; impressed sutural and subsutural bands white. Length 17.7 mm., greater diameter 12.0 mm., spire height 9.3 mm.

A darker color pattern than the usual one and a narrower form of the shell (pl. 11, fig. 30a) has the postembryonic whorls snuff brown axially streaked with russet and mars brown, and lined with a line of mars brown on the upper third of the whorl, about the periphery a band of white, lined or banded with mars yellow; impressed sutural band light ochraceous buff lightening to light buff on the last whorl. Length 17.7 mm., greater diameter 10.8 mm., spire height 9.6 mm.

The embryonic whorls of the darkest color pattern (pl. 11, fig. 31) are light buff shading to ochraceous salmon; postembryonic whorls warm sepia lightened by occasional axial streaks of mikado brown, last whorl banded just below the edge of the periphery with a band of pale cinnamon pink lined and streaked with mars yellow, on the first half of the last whorl a basal band of ochraceous orange; impressed sutural band pale pinkish buff darkening to light ochraceous buff on the last half whorl; lip and columella callus pale pinkish cinnamon deepening to pale vinaceous fawn on the outer margin. The color pattern is a rare one in the Gulick ANSP lot, but the usual one in the J. S. Emerson lot.

ACHATINELLA APEXFULVA NAPUS Pfeiffer

PLATE II, FIGURES 25-27

Achatinella napus PFEIFFER, Proc. Zool. Soc. London, 1855, p. 5, pl. 30, fig. 19.
Achatinella mustelina sordida NEWCOMB, Pilsbry and Cooke, Man. Conch., vol. 22, p. 349, pl. 30, fig. 19 (only), 1914.

The holotype (pl. 11, fig. 25) in the British Museum is marked with a red spot of sealing wax. The embryonic whorls are white;

first two postembryonic whorls cartridge buff, last whorl above the periphery vinaceous buff, at the edge of the periphery a band of cartridge buff or white, below the periphery banded with vinaceous buff, basal band about the umbilicus cartridge buff or white with faint lines of vinaceous buff; lip cartridge buff banded with vinaceous buff. Length 19.4 mm., greater diameter 10.8 mm., spire height 12.0 mm., number of whorls $6\frac{5}{8}$.

Distribution, area?: **Waialei [Waialea]**, Gulick.

The shell may have a yellow base (pl. II, fig. 26) embryonic whorls white; postembryonic whorls pale cinnamon pink; suture and sub-sutural bands slightly more dilute tint of cinnamon pink; peripheral band white, below the periphery chamois; lip and columella callus tilleul buff. Length 19.9 mm., greater diameter 12.0 mm., spire height 11.6 mm.

A larger specimen (pl. II, fig. 27) shows a darker pink color pattern and a more inflated last whorl. The postembryonic whorls are pale vinaceous fawn, banded on the lower half of the whorl above the periphery with a band of light vinaceous buff which darkens to vinaceous buff streaked with light vinaceous buff on the penultimate, and on the last whorl buff pink streaked with vinaceous buff, at the edge of the periphery a band of white, base yellow ocher lined with buckthorn brown; lip vinaceous buff, columella white. Length 20.0 mm., greater diameter 12.5 mm., spire height 11.5 mm.

ACHATINELLA APEXFULVA PAUMALUENSIS, new subspecies

PLATE 3, FIGURE 32; PLATE II, FIGURES 21, 21a

The subspecies is a highland gray race closely related to *A. a. napus*. The embryonic whorls of the holotype (pl. 3, fig. 32) are pale pinkish buff with a line of pinkish buff in the center of the lower third of the whorl; first postembryonic whorl upper half white or pallid mouse gray, lower half sorghum brown shading to pale mouse gray axially streaked with zigzag lines of benzo brown, remaining whorls spirally banded with fuscous or fuscous black, ground pale mouse gray up to the last half whorl which is shaded with light vinaceous fawn, below the periphery last whorl isabella color banded with fuscous; upper third of the impressed sutural band white or tilleul buff, remainder of the band shading from vinaceous buff to vinaceous fawn and fawn color on the last half whorl. Length 18.3 mm., greater diameter 12.2 mm., spire height 10.0 mm., number of whorls $6\frac{1}{8}$.

Distribution, area III: **Paumalu-Kaunala Ridge**, type locality 431 elevation 1,000-1,050 feet, Meinecke, 1933 (fig. 6, p. 185). Also collected by Thurston, BBM 130915.

The shell may be more strongly banded (pl. 11, fig. 21) and more obese; postembryonic whorls pallid mouse gray faintly axially streaked with mouse gray, above the periphery spirally ornamented with faint lines and a band of warm blackish brown, base naples yellow banded with warm blackish brown; the impressed sutural band vinaceous fawn on the first whorl, on the penultimate the ground color, on the last whorl the base of the band shaded with warm blackish brown. Length 18.8 mm., greater diameter 13.0 mm., spire height 9.5 mm.

One specimen (pl. 11, fig. 21a) has the postembryonic whorls warm blackish brown, banded on the first whorl with white, the remaining whorls with extremely faint lines of white or pallid mouse gray. Length 18.0 mm., greater diameter 12.1 mm., spire height 8.8 mm.

ACHATINELLA APEXFULVA OIOENSIS, new subspecies

PLATE 3, FIGURE 33; PLATE 11, FIGURES 22, 22a

The shell is a close relative of *A. a. paumaluensis*, but having a series of different color patterns; the embryonic whorls of the holotype (pl. 3, fig. 33) are pale pinkish cinnamon; postembryonic whorls above the periphery diamine brown, below the edge of the periphery of the last whorl ochraceous buff finely axially streaked with ochraceous tawny, spirally banded with a band of diamine brown and fine lines of russet, in the umbilical region a patch of black or diamine brown; impressed sutural band diamine brown; lip and columella callus fawn color. Length 18.0 mm., greater diameter 11.5 mm., spire height 10.3 mm.

Distribution, area 114: **Oio-Oio East Branch Ridge**, type locality 460A, elevation 1,300 feet, Meinecke, 1933 (figs. 6, 6a, p. 185).

The color pattern may lack the yellow base (pl. 11, fig. 22); postembryonic whorls liver brown, last whorl and a half faintly banded above the periphery, last whorl just below the edge of the periphery with a band of mars yellow almost obscured by axial streaks of liver brown; lip and columella callus pale vinaceous fawn, outer edge of the lip bone brown; impressed sutural band the color of the ground. The lightest color pattern (pl. 11, fig. 22a) has the postembryonic whorls light buff deepening to ochraceous buff on the last whorl, axially streaked with tawny, last whorl and a quarter at the edge of the periphery and about the base banded with diamine brown; impressed sutural band black. Length 17.0 mm., greater diameter 12.3 mm., spire height 8.7 mm.

ACHATINELLA APEXFULVA OIOENSIS var. 1

PLATE II, FIGURES 23-23b

Distribution, area 112: Pahipahialua Gulch, locality 450, elevation 1,250 feet, Meinecke, 1933 (figs. 6, 6a, below); also collected by Wilder, BBM 50612.

The color patterns of area 112 at first glance seem the same as those of typical *oioensis* (area 114), but close examination shows that

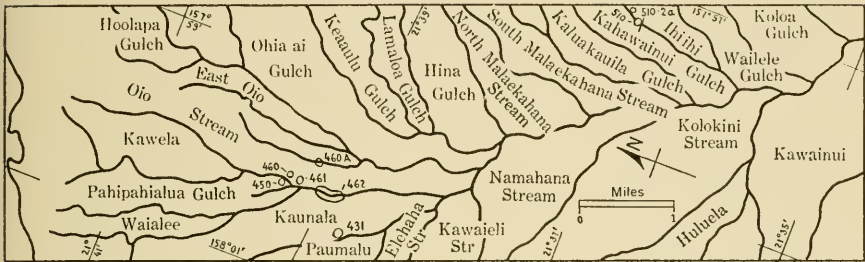


FIG. 6.—Northern Oahu, windward slope of the Koolau Range, the northwestern half of region IV (fig. 7, p. 194), showing localities of subspecies of *A. apexfulva* belonging to the groups of *A. a. apexfulva* and *A. a. aloha*.

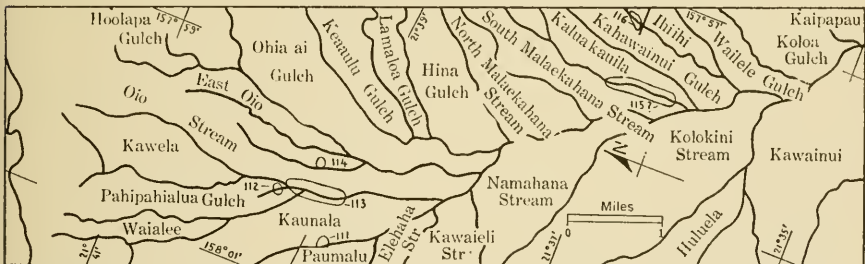


FIG. 6a.—Same as fig. 6, but showing the areas of distribution of the subspecies of *A. apexfulva* belonging to the groups of *A. a. apexfulva* and *A. a. aloha*.

slight variations occur. Usually the yellow ground color is lighter in area 112. A close reproduction of the patterns of plate 3, figure 33, and plate 11, figure 22a, is not found in area 114. Plate 11, figure 23, resembles figure 22a, but the characteristic wider sutural band of the yellow patterns of area 112 separates it from the Oio Stream forms of area 114. Moreover, dull brown forms with faint zigzag streaks occur in area 112 and do not occur in area 114.

The usual color pattern and the obese form of the shell (pl. 11, fig. 23) has the embryonic whorls pale pinkish buff; postembryonic whorls light buff very finely lined and streaked with ochraceous

tawny, at the edge of the periphery a thin band of dresden brown, base seal brown or black; sutural and subsutural bands verona brown darkening to seal brown or black on the last two whorls; lip fawn color, columella callus pale vinaceous fawn. Length 17.3 mm., greater diameter 12.6 mm., spire height 8.9 mm.

A zigzag pattern and elongate form of the shell is shown on plate 11, figure 23*a*; last two postembryonic whorls are verona brown faintly axially streaked with zigzag and straight streaks of tawny olive; impressed sutural band the ground color. Length 19.0 mm., greater diameter 12.3 mm., spire height 10.4 mm.

Only four live specimens are known from locality 450. A dark color pattern (pl. 11, fig. 23*b*) seems to be an intermediate color form between figures 22 and 23*a* of plate 11. It may be fairly close to the usual form; the last two postembryonic whorls are seal brown, at the edge of the periphery a line of yellow ocher, below the periphery a band of ochraceous buff axially streaked or spotted with seal brown, the seal brown or black base is also streaked with patches or streaks of ochraceous buff. Length 18.0 mm., greater diameter 12.5 mm., spire height 9.2 mm.

ACHATINELLA APEXFULVA OIOENSIS var. 2

PLATE 11, FIGURES 24-24*d*

Area 113: **Pahipahialua-Oio Ridge**, locality 460, elevation 1,150-1,200 feet, 3 dextral; 461, elevation 1,250-1,300 feet, Meinecke, 33 dextral 1933; **Kaunala-Oio Ridge**, locality 462*, elevation 1,300-1,376 feet, Meinecke, 1914 (figs. 6, 6*a*, p. 185). This form also collected by J. S. Emerson, BBM 102335-102336, O. H. Emerson, BBM 103986, Thurston, BBM 130954, 130950.

The shells resemble those of area 112 but have a different range of color patterns. The usual form and color pattern of the shell (pl. 11, fig. 24) has the embryonic whorls pale pinkish buff; first postembryonic whorl haematite red axially streaked with straight and zigzag streaks of pale olive gray, the last whorl and a quarter above the periphery lighter in color, being more streaked with pale olive gray and banded at the edge of the periphery with a band of pale olive gray tinted on the first half of the whorl with chamois, the base warm sepia lined with chamois; impressed sutural band mikado brown; lip and columella callus pale vinaceous fawn. Length 19.7 mm., greater diameter 12.8 mm., spire height 10.6 mm.

The color pattern may be lighter and the base yellow (pl. 11, fig. 24*a*); first postembryonic whorl and three-quarters cinnamon

drab faintly axially streaked with drab gray, below the impressed sutural band of fawn color two lines of tilleul buff, on the last whorl the ground above the periphery tilleul buff faintly axially streaked with straight and zigzag streaks of avellaneous, base mustard yellow with a band of avellaneous just below the subperipheral mustard yellow band, umbilical region lined with tawny.

An elongate shell (pl. 11, fig. 24*b*) and a variant of figure 24*a* has the postembryonic whorls white, tinted, faintly lined, and faintly axially streaked with tilleul buff or vinaceous buff; sutural and wide subsutural bands and the line below the subsutural band wood brown; on the last whorl a thin band at the edge of the periphery of drab, below which the ground is chamois banded with wood brown. Length 18.2, greater diameter 11.8 mm., spire height 10.3 mm.

The lightest color pattern (pl. 11, fig. 24*c*) has the white postembryonic whorls above the periphery lined with a faint line of naples yellow on the last whorl, below the periphery naples yellow with a central line of cinnamon, and a line and a band of russet in the umbilical region; sutural and wide subsutural bands chocolate.

A yellow color pattern (pl. 11, fig. 24*d*) has the first two postembryonic whorls pale pinkish buff, last whorl light buff finely spirally lined and axially streaked with ochraceous tawny, on the base a thin band of russet and faint lines of tawny; impressed sutural band and thin subsutural band mars brown. The wide subsutural banded form of figure 23 also occurs in this area.

ACHATINELLA APEXFULVA IHIIHIENSIS, new subspecies

PLATE 3, FIGURE 35; PLATE 11, FIGURE 34

The form is closely related to *A. a. kahukuensis* but differs in color pattern. The color pattern of the holotype resembles that of *A. a. oioensis*, but *ihiihiensis* has a base colored a lighter shade of yellow. The embryonic whorls of the holotype (pl. 3, fig. 35) are cream color; postembryonic whorls warm blackish brown; impressed sutural band cinnamon; edge of the periphery and all below the periphery of the last whorl mustard yellow, banded with a central band of warm blackish brown and two lines of mikado brown; lip and columella callus light vinaceous fawn, lip streaked with white. Length 17.7 mm., greater diameter 11.6 mm., spire height 9.6 mm., number of whorls 6.

Distribution, area 116: **Ihiihi-Kahawainui Ridge**, type locality 510, elevation 1,250-1,300 feet, Meinecke, 12 dextral 1932-1934; also locality 510-2a, elevation 1,150-1,200 feet, Welch, 10 dead specimens, 1935 (figs. 6, 6*a*, p. 185).

The shell may have a lighter color pattern (pl. 11, fig. 34); embryonic whorls light buff, faintly lined on the last half whorl with ochraceous tawny; first postembryonic whorl white, shaded with pale gull gray and banded with a central band of mars brown in the center of which is a black line, a lower band just above the periphery bone brown, divides into two lines on the last half of the penultimate, the ground on the last half of the penultimate is faintly shaded with mustard yellow, last whorl mustard yellow, banded above, below, and at the periphery with a band of bone brown at the lower edge of which is a band of mikado brown, just above the edge of the periphery are two lines, an upper of mikado brown, and a lower of bone brown, both of which fade to a lighter tint on the last half whorl; the impressed sutural band darkens from mikado brown on the first whorl to warm sepia on the last whorl. Length 18.5 mm., greater diameter 12.6 mm., spire height 9.5 mm.

ACHATINELLA APEXFULVA WAILELENSIS, new subspecies

PLATE 3, FIGURE 36; PLATE 11, FIGURE 35

The shell is not closely related to any of the known forms of *A. apexfulva*. The locality occurs far away from all the known localities of *A. apexfulva* and no intermediates between *wailelensis* and any other form are known. The shell, however, has the usual form of *A. apexfulva* and resembles *A. a. roseata* of Waimano Stream. The holotype (pl. 3, fig. 36) has the embryonic whorls white; first postembryonic whorl fawn color, last two whorls vinaceous fawn; impressed sutural band pinkish buff; lip pinkish buff, columella callus white. Length 17.3 mm., greater diameter 12.0 mm., spire height 10.3 mm., number of whorls 6.

Distribution, area, 117: **Wailele Gulch**, locality 529-1, elevation 20 feet, collected by Mr. and Mrs. G. W. Russ, and Welch 1933. The shells are found in a fossil state in a stone outcropping near the Kamehameha highway (fig. 7, p. 194).

An obese form of the shell (pl. 11, fig. 35) measures: Length 17.1 mm., greater diameter 11.9 mm., spire height 8.7 mm.; postembryonic whorls shell pink axially streaked with buff pink. A narrow specimen measures: Length 17.6 mm., greater diameter 11.2 mm., spire height 9.4 mm.

CONCLUSIONS

Gulick (1905), Pilsbry and Cooke (1912-1914) considering various species of *Achatinella* from Hawaii, and Crampton (1916, 1932) in

a study of the species of *Partula* on Tahiti and Moorea, have pointed out that tree snails vary from valley to valley in various characteristics such as size, color pattern, and form of the shell. Welch (1938) pointed out that *A. mustelina* from the Waianae Mountains of Oahu, Hawaii, not only varied from valley to valley in different characteristics, but also at different elevations on the same ridge or in the same valley.

Before discussing the variation of *Achatinella apexfulva* I will explain what is meant by a highland and lowland form. On a basis of a group of characteristics such as color pattern of the embryonic and postembryonic whorls, shape and size of the shell, I have divided the material into highland and lowland forms. On figure 7 (p. 194) two broken lines drawn across the Koolau Range outline the three zones of shell variation. Zone I contains extreme lowland forms and is probably the region where many of the extinct Gulick forms were collected. The zone occupies all the region below the lowest broken line, which extends from just above areas 117, 97A??, 37?, to just below areas 1 and 2.² Zone II contains the usual lowland forms. Gulick collected or obtained material from the lower part of this zone. Zone II occupies all the region between the two broken lines. Zone III is inhabited by highland forms and extends from above zone II to the backbone ridge of the Koolau Range. Along the border of zones II and III forms occur in certain areas which can be classed as either highland or lowland shells on a number of characteristics. The placing of these borderline areas into highland or lowland zones has been a matter of judgment and might be done differently by another worker. Areas 5??, 6??, 7??, 14??, 65??, 66??, 78?, found on figures 3, 4, and 5, have been omitted from figures 7 and 8 because I am uncertain concerning the exact location of these areas.

In the following account of shell variation in each area, the usual form³ and color pattern of the shell, generally exhibited on plates 1, 2, and 3, is taken as a basis for discussion. In some cases it was not possible to obtain a shell having both the usual form and color pattern. In that case only one of the group of characteristics is shown on one of the first three plates, such as the usual form of the shell or the usual color pattern, and the other characteristic is shown on another plate. In one case (pl. 1, figs. 27, 28) rare color patterns of a race

² An area is made up of a single locality or a group of localities containing similar forms or the same subspecies.

³ See Welch (1938) for an account of how the usual form of the shell is selected.

are shown, which distinguish the area containing them from another area of similar shells.

A. HORIZONTAL VARIATION

1. COLOR PATTERN OR COLOR OF THE EMBRYONIC WHORLS

On the color of the embryonic whorls the subspecies of *A. apexfulva* are segregated into four regions. Regions I and III have shells with bicolored embryonic whorls, and regions II and IV have unicolored embryonic whorls (fig. 7, p. 194). These four regions are further subdivided into intermediate regions Ia (area 19), IIa (areas 48, 48A, and the localities of area 47 occurring on the Manana-Waiawa Ridge), IIIa (areas 41, 42, 43, 63, and 64), IIIb (areas 61? and 62?), which contain intermediate or border forms between those of the main regions. The embryonic whorls of these border forms have a color pattern similar to that found on the shells at a similar elevation on the next parallel ridge to the southeast. This is also true of areas 40, 49, and 50.

In region IIIa the embryonic whorls are white, cream buff, or tan, faintly lined or banded with a lighter or darker color. They are intermediate between the white unicolored embryonic whorls of the group of *A. a. turgida* (region II) and the yellow banded bicolored embryonic whorls of the group of *A. a. polymorpha* (region III).

Region IIIb and areas 40, 49, and 50 definitely have the same colored embryonic whorls as found on the adjacent parallel ridge to the southeast. Region Ia contains shells with embryonic whorls which are still bicolored similar to the group of *A. a. simulans* (region I) to the southeast but are approaching the unicolored condition of the shells in region II. Region IIa has shells with slightly bicolored embryonic whorls intermediate between region II and III, but closest to the unicolored embryonic whorls of region II.

2. COLOR PATTERN OR COLOR OF THE POSTEMBRYONIC WHORLS

Many difficulties are encountered in distinguishing subspecies using color pattern for a criterion, because the same color pattern occurs again and again in colonies of shells in widely separated areas. For example, the dark typical *apexfulva* pattern from area 97 or one very similar to it, may be found in area 35 (*A. a. turgida*) (fig. 7, p. 194), area 94 (*A. a. beata* var. I), area 111 (*A. a. paumaluensis*), area 114 (*A. a. oioensis*). Pink patterns such as *A. a. lilacea* var. I in area 83 and *A. a. lilacea* possibly in area 83b?? may also be found in area 81??

(*A. a. punicca*), area 37? (*A. a. roseata*), and area 117 (*A. a. wailalensis*). Somewhere near area 40 Wilder found specimens of *A. a. perplexa* (pl. 6, fig. 19*d*) which have a pattern similar to that of *A. a. lilacea*. The various forms of *A. a. rubidipicta* can easily be taken for specimens of *A. a. rubidilinea*. White color patterns of *A. a. ovum* (area 22), *A. a. cookei* var. 1 (area 39), *A. a. bcata* var. 2 (area 108), and *A. a. roseipicta* (area 102), are very similar, differing only by a band or in the color of the lip. However, the range of color patterns of any one area always differs from that of another. Therefore, in considering horizontal variation not only the usual color pattern of the shell must be considered, but also the color pattern of the colony as a whole.

As has been pointed out before, *A. apexfulva* exhibits valley-to-valley or ridge-to-ridge variation, and the color patterns of widely separated localities are usually more strikingly different than those found on shells from adjacent areas. However, as in *A. mustelina* (Welch, 1938), *A. apexfulva* also exhibits vertical as well as horizontal variation. Therefore, when studying horizontal valley-to-valley variation it is important that both localities or areas under consideration are from approximately the same elevation or in the same lowland or highland zone such as zones I, II, or III.

I do not like to use the word elevation because two localities on opposite ridges may be at an equal distance from the backbone ridge and yet because of a hill on one ridge and a depression on the other, one locality may be definitely higher than the other. Again, one locality may be in a valley, the other on a nearby ridge, the two showing a wide difference in elevation. The distance a locality is from the backbone ridge or in what zone a shell is found is of greater importance than differences of several hundred feet in altitude. Therefore, zones and not differences in elevation will be discussed.

I have already noted above that the color of the embryonic whorls varies in regions I, II, III, IV. The color pattern of the shell not only shows marked variation between each of the four regions, but also less variation within each region. For instance a series of areas in region II zone II will have rather similar color patterns. In like manner a group of areas in region III zone II will have another series of similar patterns but which are markedly different from those found in region II zone II. In most areas occurring at similar elevations or in the same zone on opposite ridges in a certain region the color pattern of the shells are similar. However, in the region of Waimano Stream the color patterns of such opposite areas—for example, areas 44 and 43—are not similar. Area 44 has patterns

similar to those of area 50 above area 43 (fig. 4, p. 53). Also, the shells of area 45 on the Waimano-Manana Ridge more closely resemble the shells of area 49 above area 50, although area 50 is opposite area 45. In like manner the color patterns found in any zone in region III will definitely differ from those found in region IV. The same holds true for regions I and II.

In between the regions of major differentiation intermediate or border areas occur, such as regions Ia, IIa, IIIa, IIIb, and areas 40, 49, 50. Region Ia contains forms which have a color pattern intermediate between regions I and II, zone II, but closer to the color pattern of the shells to the southeast, or region I. Region IIa and IIIb and areas 49 and 50 have shells the color pattern of which is very similar to that of the shells to the southeast and entirely different from those to the northwest in the same zone. Region IIIa and area 40, zone II, contain gray color patterns which are close to the color patterns of region III, zone II, and very different from those to the southeast.

As a general rule more horizontal variation occurs in zone II than in zone III. This can be explained by the fact that usually the lower reaches of a ridge fans out into several long ridges. Consequently, there are more ridges and valleys at low elevations or in a lowland zone, which increases the possible number of isolated colonies in zones I and II as compared with zone III.

Today the isolation of the lowland colonies is more complete than it was originally because of the dying out of the forest and the spread of the staghorn fern (*Gleichenia linearis*). In this manner groups of trees are isolated from other groups of trees so that snails cannot possibly migrate. This is more especially true of lowland forms in zone II and the lower portions of zone III. In many places trees exist only in the bottom of a gulch the sides of which are covered with staghorn fern, while the tops of the intervening ridges are covered with grass. Again the trees on the side or summit of a ridge may also be surrounded by staghorn fern.

In zone III, which includes the upper part of Hosaka's (1937) Ohia Zone and all of the Cloud Zone (fig. 1, p. 3), the forest is more continuous, although in many regions large sections are covered with staghorn fern. One would expect more horizontal migration here because of the relatively larger amount of flora, greater rainfall, and the connection of the backbone ridge with the main ridges of the Koolau Range, which would afford a road for migration. On the other hand the peaks of the backbone ridge might also serve as effectual barriers. But *A. apexfulva* does not occur at the backbone

ridge. When it is collected on a ridge, the highest locality is usually a mile or more below the backbone ridge. An exception to this is area 1, which is nearer the backbone ridge. Area 115? is only an approximate locality and so cannot be considered (fig. 7, p. 194). The Nuuanu localities of area 10 are on subridges in the valley separated from the backbone ridge by a high precipice. On the other hand, although the forests are fairly continuous in zone III, migration from one ridge to another would be impeded by the gulches which contain water.

Whether there is any horizontal migration in zone III is not known. The forms in regions I, II, III, and IV, zone III, are certainly distinct from each other but have color patterns that are more similar to each other than are the color patterns in the same regions in zone II. I do not believe that the more extreme horizontal variation in zone II is entirely due to isolation which has come about in the last 50 or 100 years, because forms of *A. apexfulva* seem to colonize limited areas and to break up into different varieties or subspecies at different elevations or at short distances from an adjacent colony. This is especially true of zone II, which has less rainfall than zone III and consequently would tend to discourage migration. Nevertheless, the present-day extreme isolation and inbreeding of certain groups of genes undoubtedly accentuates the former horizontal valley-to-valley variation. The characteristic of *A. a. apexfulva* of breaking up into varieties in limited areas differs from what Crampton found (1916, 1932) in species of *Partula*, which apparently migrate into various adjacent areas and do not change color pattern in doing so.

3. SIZE

Table 2 (p. 15) gives the statistics of length range, mean length of shell, and number of dextral and sinistral shells found in each locality having a series of five shells or more with a length range of at least three sizes such as 18.5 mm., 19.5 mm., 20.5 mm. The means of the shells are grouped into length classes. For example, everything between 17.76 mm. and 18.25 mm. is considered 18.0 mm. and everything between 18.26 mm. and 18.75 mm., is taken to be 18.5 mm. This was also done in the paper on *A. mustelina* Mighels (Welch, 1938). In the following discussion on size variation the mean length of the shell will be referred to without needlessly repeating the words "mean length of shell."

The various localities or areas containing forms of *A. apexfulva* are grouped for convenience into 20 ridge complexes or ridge groups in order to demonstrate size variation. A ridge complex such as 3 (fig. 8, p. 195) may be a single ridge which fans out near the

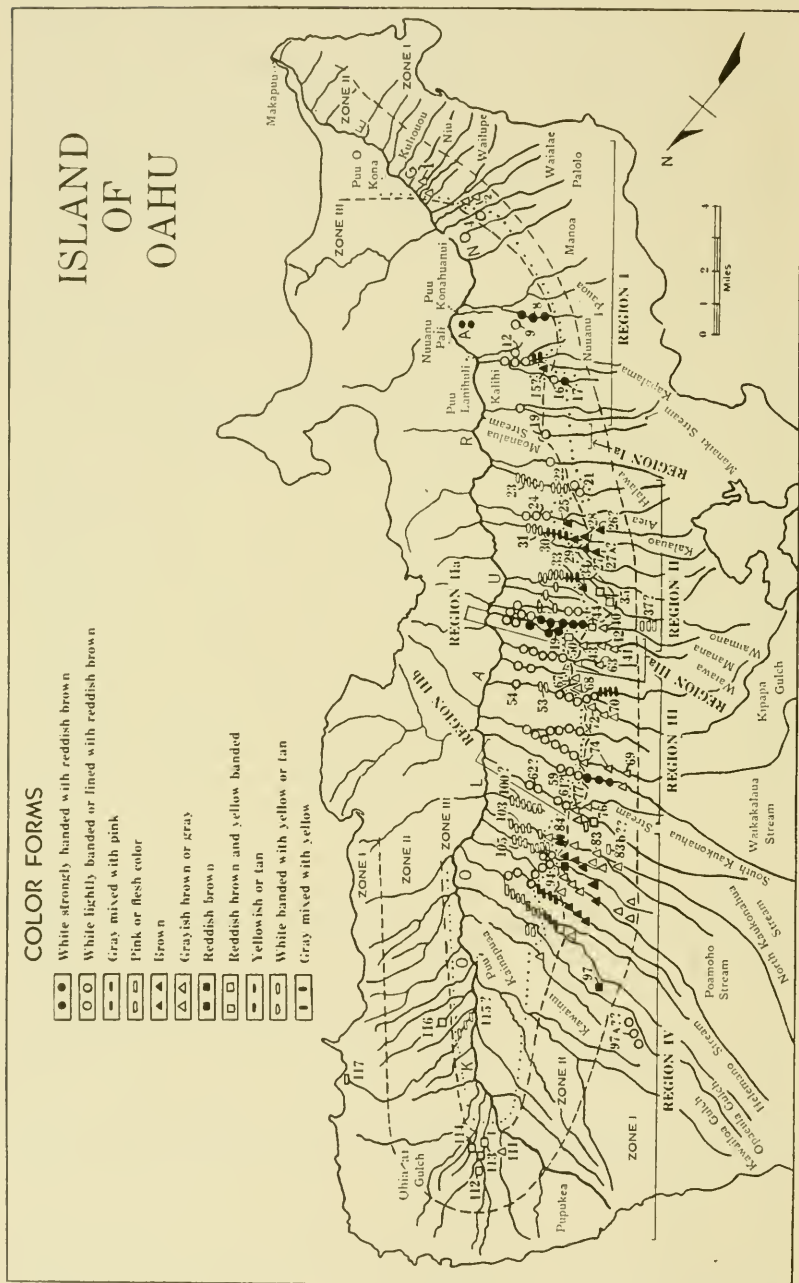


FIG. 7.—Distribution of color forms of *A. apertiflora* in the Koolau Range.

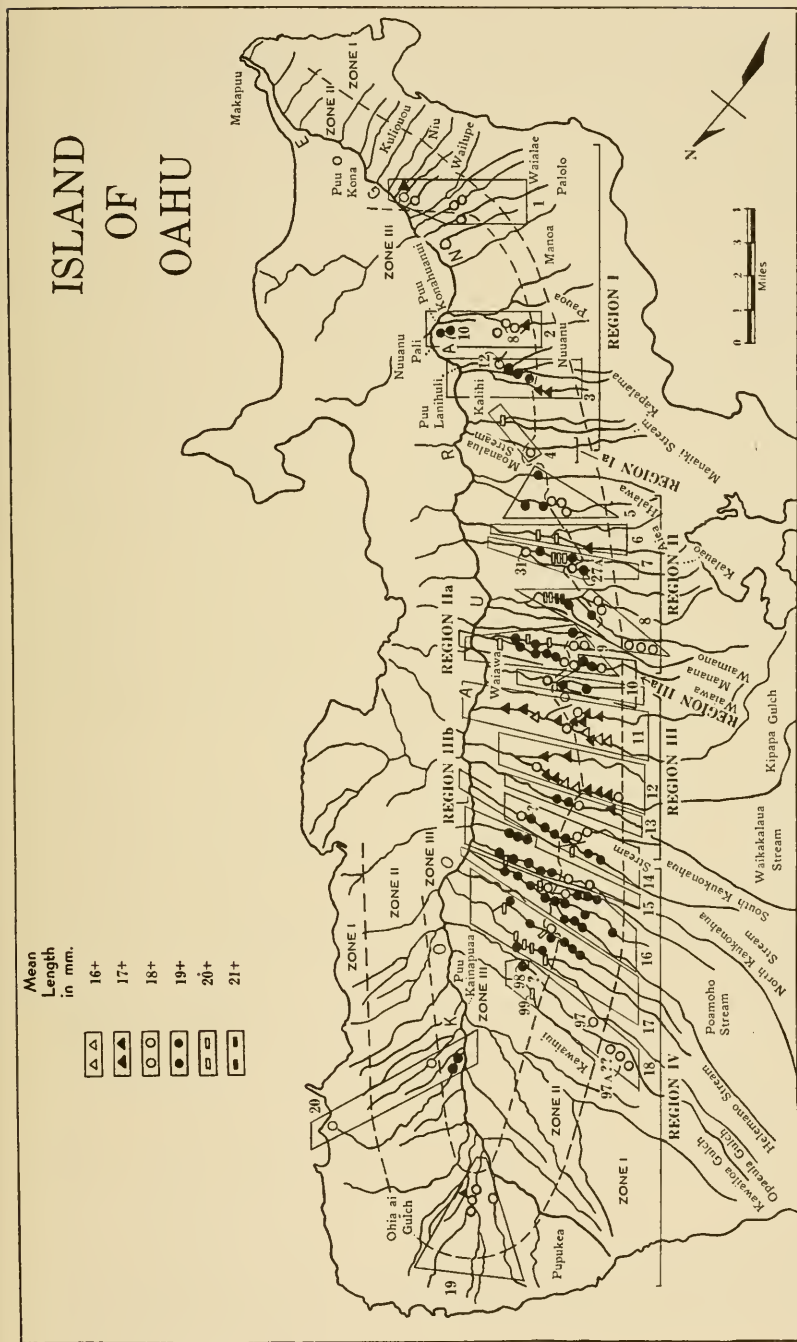


FIG. 8.—Shell-size variation of *A. apexfulva* in the Koolau Range.

terminus into four main ridges and includes not only all localities on these ridges but also all localities in valleys adjacent to or in between these ridges. Again if only one or two areas are reported from one ridge (4, 5, 12, fig. 8, p. 195) they are included with the ridge complex of the adjacent ridge, or with an area in an upper or lower portion of an adjacent ridge. With the exception of ridge complexes 1, 19, 20, which are groups of ridges, no ridge complex includes more than two main ridges, which arise from the backbone ridge of the Koolau Range. In compiling table 2, all forms from a ridge complex are grouped together. Those from localities at the lowest elevations (zones I and II) are given first and followed by forms from localities at successively higher elevations (zone III). The exact localities of most of the extinct Gulick forms are unknown, and they are placed in table 2 next to the ridge complex which probably contained them.

On figure 8 (p. 195) size variation of *A. apexfulva* in the Koolau Range is illustrated. The data given in table 2 are used for compiling the map. Where space permits, the length of the shell for each locality is plotted with the appropriate symbol. Usually there is not enough room to plot each individual locality, so that a symbol may stand for several localities or an entire area having the same shell length. The shell length of the majority of localities in an area is plotted where there is not enough room to plot the shell length of one or more localities having different shell lengths. If three lots from a single locality have three different lengths such as 17+, 18+, 19+, the middle length of 18.5 is chosen for plotting. All data from localities collected after 1932, or from localities I believe to be reliably plotted, are used in preference to less reliable material such as Wilder's and that of other collectors which has been localized by being matched with reliable material. Material which has been localized from localized data is included because in some cases it contains large series which furnish additional data as to the possibilities of size variation of a form. In some cases the localized material is represented by such small lots that it is of little statistical value.

Shells in highland localities (zone III) show as much horizontal size variation as those in lowland localities (zone II). The shells in zone I cannot be considered because of insufficient data. Little is known about zone I, and the three widely separated localities on the map in figure 8 are the only ones in zone I concerning which there are any data. They show no horizontal variation. If more were known about the location of the Gulick localities more variation would be noted in zone I. The Gulick shells came from zone I and lower zone II. Only

the Bishop Museum's portion of the Gulick collection is measured, with the exception of one Gulick lot of *A. leucozona* in the Academy of Natural Sciences of Philadelphia. This is approximately only 22 percent of the entire Gulick collection, which was broken up into 20 separate collections by Gulick. Many specimens were also traded with people all over the world by Gulick, so that 22 percent may be too high an estimate.

The Gulick material used, therefore, cannot be statistically significant, but does give an approximation of size variation of at least those series which are measured. In the region of ridge complexes 1 and 2 (table 2) 17+ shells are dominant in the Gulick lots, whereas in the region of ridge complexes 14, 15, and 19 the mean length ranges from 16+ to 17+. The 19+ forms from the region of ridge complex 15 are probably from zone II.

Zone II shows marked size variation in certain regions. Groups of ridge complexes have similar shell lengths and the change in some regions from large to small shells is abrupt. Half the ridge complexes (1, 4, 5, 7,⁴ 8, 9, 15, 18, 19, and 20) contain mostly 18+ shells, 22 percent (ridge complexes 10, 14, 16, and 17) have mostly larger 19+ shells, and 27 percent (ridge complexes 3, 6, 11, 12, and 13) contain small 17+ shells but may also have 18+ shells. Small 16+ shells occur only in ridge complex 11.

Twenty-two percent of the ridge complexes (1, 10, 11, and 12) in zone III have small 18+ or 17+ shells. The remaining 78 percent of the ridge complexes, including number 2 (fig. 8, p. 195) have 19+ or 20+ shells, and in ridge complex 8, 21+ shells also occur. Only the uppermost localities in ridge complex 2 contain 19+ shells, the lower localities having small 18+ or 17+ shells. If size alone were considered, these lower localities would be placed in zone II. In ridge complex 3 (fig. 8, p. 195) what appears to be the highest area contains 18+ shells. Actually this area (area 12, fig. 8) is on the lower portion of a small spur ridge in ridge complex 3 and is at a lower elevation than the other localities. Ridge complex 7 also has 18+ shells in zone III (area 31, table 2). This may be due to the small number of shells measured; possibly if a larger series were obtained, the mean length would be greater.

⁴Area 27A?, the lowest area in ridge complex 7, has a mean length of 18.77 mm. and is therefore represented in figure 8 by the symbol for the 19+ class shells. However, it really is very close to the 18.5 class and could be considered an 18+ area.

B. VERTICAL VARIATION

I. EMBRYONIC WHORLS

No vertical variation in the color of the embryonic whorls occurs in regions I, II, IIa (fig. 7, p. 194). Vertical variation occurs between regions IIIa and the portion of region III immediately above IIIa, and on the North-South Kaukonahua Ridge between regions IV and IIIb. The lower regions have shells with unicolored embryonic whorls (region IV) or with embryonic whorls that are intermediate between the bicolored and unicolored condition (region IIIa). The upper regions III and IIIb on the other hand have shells with bicolored embryonic whorls (fig. 7, p. 194).

In area 77, between regions IV and IIIb, shells of *A. a. tuberosus* var. 3 have either unicolored or bicolored embryonic whorls. In the Gulick collection specimens of *A. a. polymorpha* have either bicolored or unicolored embryonic whorls. This may indicate that at a low elevation (zone I) in the region of Waiawa and Kipapa Gulch shells with unicolored embryonic whorls existed below the present-day forms with bicolored embryonic whorls in zone II of region III.

Region IV contains only shells with unicolored embryonic whorls but northwest of North Kaukonahua Stream to Opaepala Gulch in the lowest areas (areas 85, 86, 89, 90, 91??, 92, 93, 95, 96, 106, 107, 109, fig. 5a, p. 105), the shells have dark embryonic whorls which are some shade of brownish yellow such as ochraceous tawny or buckthorn brown. The upper localities have lighter embryonic whorls with such colors as white, light buff, or pale pinkish buff. An exception to this rule is area 88, which contains shells with darker embryonic whorls than lower area 87. Area 97 of Opaepala Gulch (ridge complex 18, fig. 8, p. 195) has shells with darker embryonic whorls than those of area 99 above it. But area 97A??, which is below area 97, has shells with white embryonic whorls. So that in the region of Opaepala and Kawailoa Gulch three distinct types of embryonic whorls occur: Highland white or buff, lowland brownish, and finally white in the extreme lowland shells. Northwest of Kawailoa Gulch no vertical variation is noted in the color of the embryonic whorls in shells found today.

2. COLOR PATTERN OF THE POSTEMBRYONIC WHORLS

The postembryonic whorls show more vertical variation than the embryonic whorls. At different elevations along a ridge different colonies or areas with distinct color patterns are encountered. The

vertical variation between two areas is usually more marked than the horizontal variation. In studying the patterns of any area or locality in relation to other forms, not only must the shells in areas on adjacent ridges on either side be considered, but also those above and below the area on the same ridge.

The color patterns of the Koolau Range can be divided into light and dark. The light patterns are: 1, white strongly banded with reddish brown; 2, white lightly banded or lined with reddish brown; 3, white banded with yellow or tan; 4, pink or flesh color, which may be banded with white. The dark color patterns are: 1, gray mixed with pink; 2, brown; 3, grayish brown or gray; 4, reddish brown; 5, reddish brown banded with yellow; 6, yellowish or tan; 7, gray mixed with yellow.

The division of color patterns into light and dark forms in the Koolau Range, while very close to the division of patterns between zones II and III, is not the same. A dotted line has been drawn (fig. 7, p. 194) showing the boundary between highland light color patterns, usually present in zone III, and lowland darker patterns not dominantly banded with white, which exist below the line in zone II and lower zone III. With the exception of areas 30 and 33 (fig. 7, p. 194), which contain dominantly yellow patterns, all forms above the dotted line are white forms banded with various colors, usually reddish brown or yellow. In all areas below the dotted line, with the exception of area 97A??,⁵ not only are the shells darker in color but also the patterns are axially streaked. Area 70, below the dotted line, has white color patterns which are distinct from the highland forms in being tinted with gray and in not having the white ground color found on shells above the dotted line. Pink shells from lowland areas (37?, 83b??) differ from pink shells found above the dotted line in not being banded with white and in lacking white color patterns.

Therefore, the color pattern of shells coming from areas of high humidity (most of zone III) tends to be dominantly white and banded, while shells with darker patterns which are banded and streaked occur in dryer situations (lower zone III, zone II, and zone I). Although banded patterns are not characteristic of highland or lowland forms, streaked patterns with the exception of area 97A??, seem to be characteristic of shells inhabiting dry situations. This cor-

⁵ Area 97A?? contains white color forms lightly lined and banded and not markedly axially streaked. This locality is an exception to the general rule concerning the color pattern of lowland color forms.

relation between pattern and elevation in *A. apexfulva* was noted by Pilsbry and Cooke (1912-1914) and Welch (1938a). No correlation exists between a particular pattern and a definite altitude.

The shells of area 1 (fig. 8, p. 195) are near the backbone ridge and would be expected to contain white shells and be part of zone III. However, area 1 contains lowland dark streaked gray forms although it is at a higher elevation than area 3, where white shells occur. As regards moisture conditions, area 1 is found to be in a section of relatively low humidity as compared with most localities to the northwest in zone III. Northeast of Nuuanu near the backbone ridge the rainfall decreases the farther one goes to the northeast (compare Luakaha (upper) with Makapuu, table 1, p. 10).

Region I, northwest of Palolo, shows less variation than the other regions. This is probably due to the fact that the lowland localities are all wiped out and only the upper less variable forms exist today. However, from what is known of shells collected by Gulick and older collectors in the region of Nuuanu-Kalihi, there existed a number of small dark-colored races of shells below the present-day white races. Area 15 is the only area in the Nuuanu-Kalihi region with markedly dark color patterns.

Little vertical variation is shown in the Halawa section of region II. Area 21 has white shells, above which in areas 22 and 23 the dominant pattern is white but contains yellowish banded and lined forms which are darker than those found in area 21. Two of these rarer darker patterns from area 23 are shown on plate 1, figures 27 and 28.

The shells in area 26 are brown, banded with white, and are lighter in color than those higher up the ridge, which are yellow banded with brown in area 25. Above area 25, the usual color pattern is white. North of Kalauao to Waimano, the lowland areas have shells with brown patterns grading into yellow at a higher elevation and finally, in area 31, into white. In Waimano, in area 34, brown patterns occur which also grade to yellow and finally to white in the upper areas. But below area 34, in area 35, reddish-brown patterns are found, and these occur also in areas 44 and 50. Above these last two areas the shells of the upper areas have patterns that contain more and more white and are less heavily banded with reddish brown.

North of Waimano, in regions III, IIIa, and IV, the predominant lowland patterns, zone II and lower zone III, are brown or gray with here and there an area of reddish-brown, yellow, or pink shells. Above these in zone III the color patterns are all white. Region IV is the section of the Koolau Range which shows maximum vertical

differentiation. The contrast between lowland streaked and highland banded patterns is very marked. On some ridges as many as 7 or 8 distinct color races are found (see pl. 2, figs. 24-30; pl. 3, figs. 1-8, 12-18, for examples of forms occurring on three ridge complexes).

North of Kawaihoa Gulch no particular zoning is known to occur today in ridge complex 19. But in Gulick's day there must have been a division between *A. a. napus* and the darker reddish-brown forms that occur today in areas III, II2, II3, II4.

3. SIZE

Thirteen ridge complexes (2-6, 8-9, 13-15, 17, 18, and 20, fig. 8, p. 195) show size increase in the majority of localities with increase of elevation. The smaller lowland shells, with the exception of area 2, are in zones I and II and are usually 17+ or 18+ mm., with here and there a locality with 19+ shells. In area 2 all forms are in zone III, but all the lowest localities have small 18+ or 17+ shells, similar in size to those usually found in zone II, while the highest locality contains 19+ shells. In all the remaining 12 ridge complexes showing size increase in zone III, the shells are 19+ or 20+ mm. Although there is a contrast between zones II and III the increase in size is not a gradual one. The highest localities do not contain the largest shells. Northwest of ridge complex 7, 19+ shells occur above 20+ shells in many localities. In ridge complex 8, 20+ shells occur above 21+ shells. Ridge complex 3, area 12 (table 2), has 18+ shells and appears on figure 8 (p. 195) to be at a higher elevation than the 19+ shells. However, the shells were collected on a small spur ridge of ridge complex 3, probably at a lower elevation in Nuuanu than the 19+ shells. The exact extent of the locality is uncertain.

The 18+ sinistral shells from area 62?, ridge complex 14 (table 2), are reported from the same locality as the larger 19+ dextral shells, and are separated because of the size difference. If both dextrals and sinistrals are lumped together, the mean length is 18.0 mm. The locality was plotted 13 years after being collected and probably represents two localities, one of dextral and one of sinistral shells. On figure 8, ridge complex 14, 18+ shells are plotted above 19+ shells, which may be an error. Whether the dextral or sinistral shells occur in separate localities, or one above the other, is of no great importance. The small 18+ shells are of interest because they are another exception to the general trend.

Out of the seven ridge complexes not showing altitudinal size variation, two can be disregarded. One of these, ridge complex 19, is

all in zone II; the other, ridge complex 10, is represented by only one locality in zone III, which contains only five specimens. The remaining five ridge complexes show no marked variation in the majority of localities between zones II and III. Ridge complex 1 contains only 18+ shells, regardless of altitude. If the Gulick shells from this general region, probably zone I and lower zone II, are compared with present-day forms, size variation can be noted. The lower Gulick forms are 16+ or 17+ shells. However, if all the Gulick shells in institutions outside of the Bishop Museum collection were measured and considered together, the mean length might be greater, probably 18+ instead of 17+. The highest locality in ridge complex 7 (area 31, table 2, p. 15) has 18+ shells, while the lowest locality (area 27A?) has shells with a mean length of 18.77 mm., or 19+ shells. In between these localities, 19+ and 20+ shells occur.

The most remarkable exceptions to altitudinal size increase are ridge complexes 11 and 12, which have small 17+ shells occupying the majority of localities in both zones II and III. In ridge complex 11, zone III, 16+ shells also occur. Localities of 18+ shells are found here and there in both zones II and III in both these ridge complexes.

As with *A. mustelina* (Welch, 1938), no clear-cut correlation can be drawn between increase of moisture and size variation. The highest localities in ridge complex 1 near the backbone ridge range in elevation from 1,650-2,000 feet, while those in ridge complex 2 range from 1,150-1,500 feet. However, the rainfall in upper ridge complex 2 is undoubtedly greater than in upper ridge complex 1, for although there are no rain-gage stations in this region, south of Nuuanu and Manoa the backbone ridge undoubtedly receives less rainfall (compare Luakaha (upper) with Makapuu, table 1, p. 10), so that in this case a correlation can be drawn between increase of size and increase of moisture. In a similar manner the localities in area 8, which is a much dryer section of Nuuanu Valley than area 10, have smaller shells than the upper locality even though the elevation of both areas is about the same (compare Luakaha upper and Luakaha lower, table 1, p. 10). While a correlation can be drawn between an increase of size with an increase in moisture conditions in ridge complexes 1 and 2, it is not possible on the same basis to explain the small shells of ridge complexes 11 and 12, zone III, or the larger 19+ shells of ridge complexes 7, 16, and 17, zone II.

Even though exceptions occur at random, 65 percent of the ridge complexes show a size change between zone II and III. A correla-

tion, then, can be drawn in the majority of ridge complexes between increase of size with increase of moisture and lower temperature. This is the reverse of what was found for *A. mustelina*, which species shows a correlation between decrease of size and increase of moisture. Therefore, these two different species react very differently to similar environmental conditions, the reaction probably depending not only on the genetic make-up of the individual but also on the influence of the environment on the hereditary factors.

4. SHAPE

If the usual form of the shell from each area is considered and the ratio of the length to the greater diameter is obtained, the usual form of the shell is found to vary at random. Only in ridge complex 15 is any vertical variation shown; here the lower areas contain narrower shells than the highland areas. This general condition is similar to that found in the case of *A. mustelina* (Welch, 1938). In most areas in the Waianae Mountains *A. mustelina* showed no vertical variation. Only in the northern section of the mountains is the shape of the shell found to change from elongate lowland to more squat highland forms.

C. VARIATION WITHIN A LOCALITY OR AREA

I. COLOR PATTERN OF EMBRYONIC AND POSTEMBRYONIC WHORLS

Each subspecies in a given locality has a range of color patterns from light to dark. The dark color patterns of shells from some areas in zone III in regions I and II are often very different from the usual white color form of the shell. In area 8 (pl. 4, fig. 15*b*), area 12 (pl. 4, fig. 20*b*), area 11 (pl. 5, fig. 2*b*), area 10 (pl. 5, fig. 1*a*), and area 46 (pl. 7, fig. 14*a*) dark reddish-brown forms occur which would never have been expected in an area of white shells. One of the most striking examples of this occurrence of two widely differing color patterns from the same locality is to be seen in the region of the North Kaukonahua area 103 of *A. a. roseipicta* var. 1. The dominant color pattern (pl. 3, fig. 8) is a pinkish one banded with white, and the other color patterns are white ones banded with pink. With these patterns, a few rare dark gray color forms occur (pl. 12, fig. 6) which are strikingly different. The same thing occurs in area 105. In area 100? the strikingly banded patterns of *A. a. aloha* var. 1 may be an example of the same thing, but in this locality the patterns are not only different but show a series of variants which may indicate a separate area containing special color patterns.

2. FORM

A considerable amount of trouble has been taken to show the range of form variation within each area. The extreme narrow and obese forms of the shell are generally figured for each form and the measurements given in the text. For example, various forms of *A. a. turgida* have been figured on plate 6. The extreme obese form of the shell (pl. 6, fig. 4a) looks very different from the narrow form of the shell. The spire may be concave in outline (pl. 6, fig. 4e) or straight in outline (pl. 6, fig. 5). The contrast between the narrow (pl. 5, fig. 17) and the obese form (pl. 5, fig. 17a) of *A. a. bruneola* is enough to lead to the consideration of the specimens, disregarding color, as two different forms. In like manner specimens of *A. a. parvicolor* (pl. 6, figs. 15, 15a) also show marked variation, as do many other subspecies. Just as with color pattern, the shape and size of the shell cannot be used as a criterion in determining a species, unless a series of forms are available so that something is known about the range of variation.

D. SIZE VARIATION IN THE SAME COLONY OVER A PERIOD OF YEARS

There is little information on this question. *A. a. rubidipicta* (area 11, ridge complex 3) collected from 1921 to 1929 shows little variation over a period of years (see table 2, p. 15). *A. a. turgida* (area 35, ridge complex 8) collected from locality 202b from 1920 to 1934 shows no variation in the mean length of the shell over a period of 14 years. However, a lot collected in 1913 (table 2) is smaller than the lots collected in 1920 to 1934. This difference in size of the 1913 lot might be interpreted to be a size change or evolutionary change occurring in a period of 7 years, but I believe it is more likely the result of an error due to the small number of shells or to the collecting of the shells in a locality slightly different from, or lower than, that where later collections were made.

As in the case of *A. mustelina* Mighels (Welch, 1938, p. 142), I do not believe any evolutionary change has brought about a difference in the size of shells of *A. apexfulva* collected 20 years ago and those collected in the same locality today. This differs from Crampton's (1916, 1932) findings in his study of *Partula* of the Society Islands.

E. DEXTRALITY AND SINISTRALITY

No order is found in the occurrence of dextral and sinistral forms either horizontally or vertically. Ridge complexes 15-20 are domi-

nantly dextral, while ridge complexes 1-14 contain both dextral and sinistral shells with the exception of ridge complexes 2 and 4, which have only sinistral forms.

F. THE EFFECT OF THE HABITAT ON SUBSPECIATION

Gulick (1905) does not believe that natural selection due to external conditions explains the diversity of species in *Achatinella*. He points out that climate, soil, and vegetation are essentially the same from valley to valley. He discounts the effect of differences in the amount of rainfall in a locality on speciation, because forms from the south-east slope of the Koolau Range show more divergency among themselves than those on opposite sides of the Koolau Range, even though the rainfall is greater on the northwestern or windward slope than on the leeward slope. Gulick collected most of his material at a low elevation below 1,500 feet. He had no material that showed any possible variation between a lowland dry locality and a highland more humid locality in the same valley or on the same ridge. The diversity of forms on opposite sides of the Koolau Range is certainly as great as, if not greater than, that found between forms on the same side of the mountains.

Crampton (1932, p. 208), in his study of *Partula* from the Island of Moorea, states:

With reference to the problem of the possible effects of the environment upon structural or other qualities the only conclusion warranted by the facts is that congenital factors are solely responsible for the diversities exhibited by the several varieties, by the numerous colonies, and by the individual components of the colonies.

Dobzhansky (1937, p. 136) believes that while it is difficult to prove that a given trait is not, or has not been, influenced by adaptation to the environment, nevertheless the facts given by Crampton and Gulick are explainable on the assumption that racial differences are merely due to random mutations and to random changes of gene frequencies in isolated populations. In discussing Wright's papers on evolution Dobzhansky (1937, p. 134) explains how species may be differentiated into subspecies. Such an explanation applied to *A. apexfulva* would satisfactorily account for valley-to-valley variation. However, it does not explain why there is a definite vertical change in color pattern along a definite line such as the dotted line in figure 7 which divides highland dominantly white color patterns from lowland dark color patterns. If variation is purely a matter of the random combination of genes and mutations within a locality, both highland

and lowland localities have an equal chance of having dark or light color patterns and should occur in both areas at random. Possibly, then, other factors such as difference in moisture conditions, temperature, differences between a highland and lowland flora, and various other ecological factors are playing a role. The highland set of external factors may be favorable to white color patterns, while the lowland ones favor the survival of dark patterns.

These data indicate that subspeciation within the species *A. apexfulva* is due both to the effects of random variation in partly isolated populations and to selective factors in the environment.

SUMMARY

1. The various forms of *A. apexfulva* are organized into subspecies. New subspecies to the number of 43 are recognized from a total of 78 forms.

HORIZONTAL VARIATION

2. The embryonic whorls may be either bicolored or unicolored. Shells with bicolored embryonic whorls occur in regions I, III, and IIIb; those with unicolored ones occur in regions II and IV. Regions Ia, IIa, and IIIa have embryonic whorls which are intermediate between the bicolored and the unicolored condition.

3. The color pattern of the postembryonic whorls shows marked differentiation between regions I, II, III, and IV, and less variation within each region. More horizontal differentiation occurs in zone II than in zone III. No horizontal migration is noted of one form invading the territory of another, because *A. apexfulva*, like *A. mustelina* (Welch, 1938), tends to break up into subspecies at different elevations and at short distances away from a given colony.

4. Highland forms occurring in zone III show as much horizontal size variation as lowland forms in zone II. Half the ridge complexes in zone II have 18+ shells, 22 percent have 19+ shells, and 27 percent have a mixture of 18+, 17+, and 16+, shells. In zone III 22 percent of the ridge complexes have 18+ or 17+ shells, while 78 percent have 19+, 20+, or 21+ shells.

VERTICAL VARIATION

5. Vertical variation occurs in the color of the embryonic whorls between regions IIIa and III, and between regions IV and IIIb. Regions III and IIIb have shells with bicolored embryonic whorls,

region IV has shells with unicolored embryonic whorls, and region IIIa has embryonic whorls intermediate between the bicolored and unicolored condition. In ridge complex 18, area 97A?? (fig. 8, p. 195) has shells with white embryonic whorls; above this area (area 97) shells with yellowish-brown embryonic whorls are found; and in areas 98 and 99 at a still higher elevation shells with lighter buff embryonic whorls occur.

6. The color pattern of the postembryonic whorls varies at different elevations, and this variation is usually more marked than the horizontal variation. Shells from areas having a high rainfall tend to be white and to have banded patterns; those occurring in dryer situations (lower zone III, zone II, and I) tend to have darker patterns which are banded and streaked. The region of maximum vertical variation is region IV.

7. Out of 20 ridge complexes, 13 show size increase with increase of altitude between lower zone II and higher zone III. The remaining ridge complexes are exceptions to the general trend. Although the correlation is not so clear-cut as for *A. mustelina*, a definite tendency toward size increase with increase of moisture and lower temperature exists in *A. apexfulva*, just the reverse of the correlation for *A. mustelina*.

FORM AND COLOR

8. The shape of the shell varies at random both vertically and horizontally.

9. No order in the distribution of dextral and sinistral shells is ascertained.

10. Color variation within a locality is often very extensive. This makes it necessary to study large series in order to ascertain whether a form is a distinct race or merely a color pattern of a known subspecies. The same color pattern may occur again in a number of widely separated localities. The embryonic whorls may be unicolored or bicolored in the same locality.

11. Form varies a great deal within a locality. A subspecies may have narrow or obese shells. The spire may be straight, concave, or convex in outline. Therefore, form is no criterion for the naming of a species or subspecies until the range of variations of a series of specimens is studied.

12. Over a period of years no size variation was noted in shells from a definite locality. However, little data was available on the subject.

SUBSPECIATION

13. Subspeciation in *A. apexfulva* is believed to be caused by both the effects of random variation in partly isolated populations and selective factors of environment.

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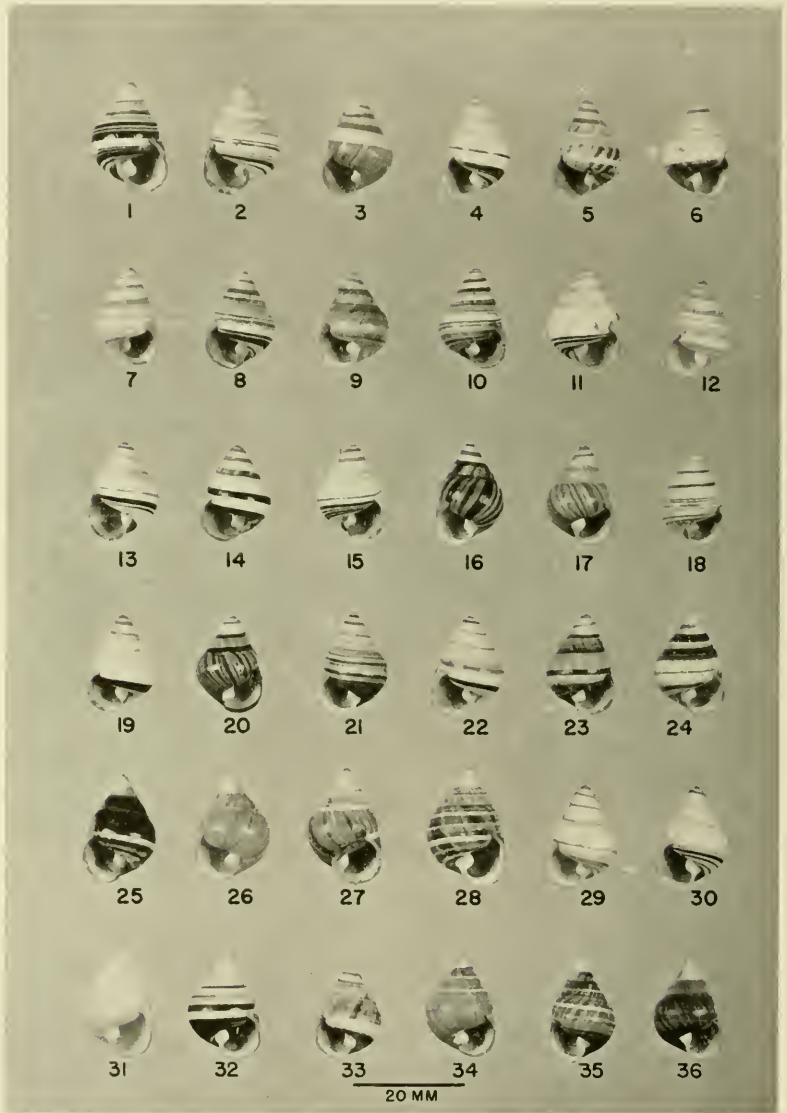
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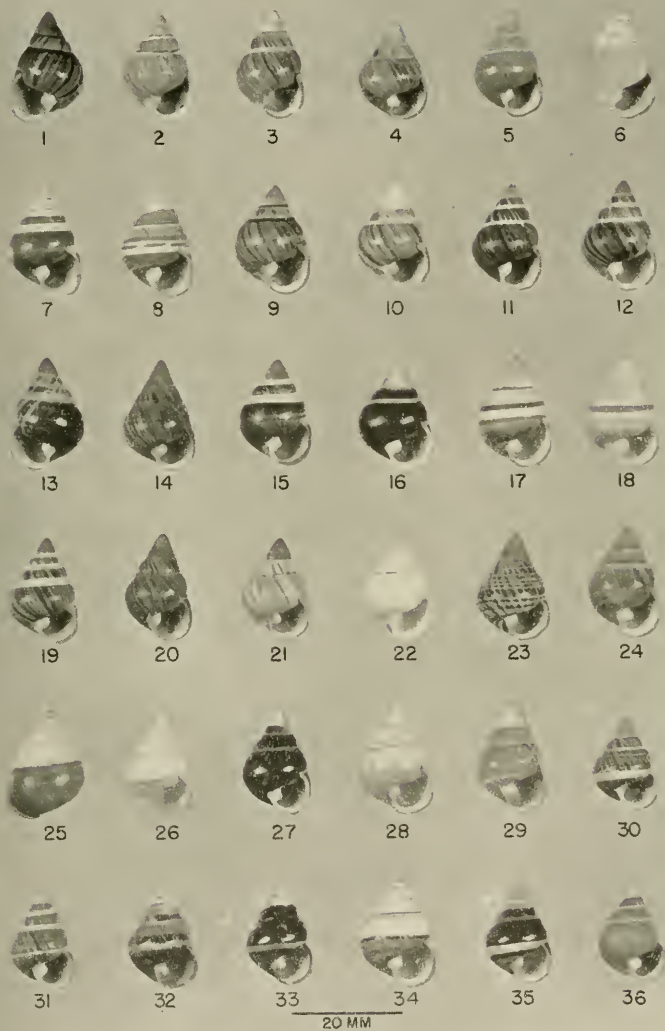
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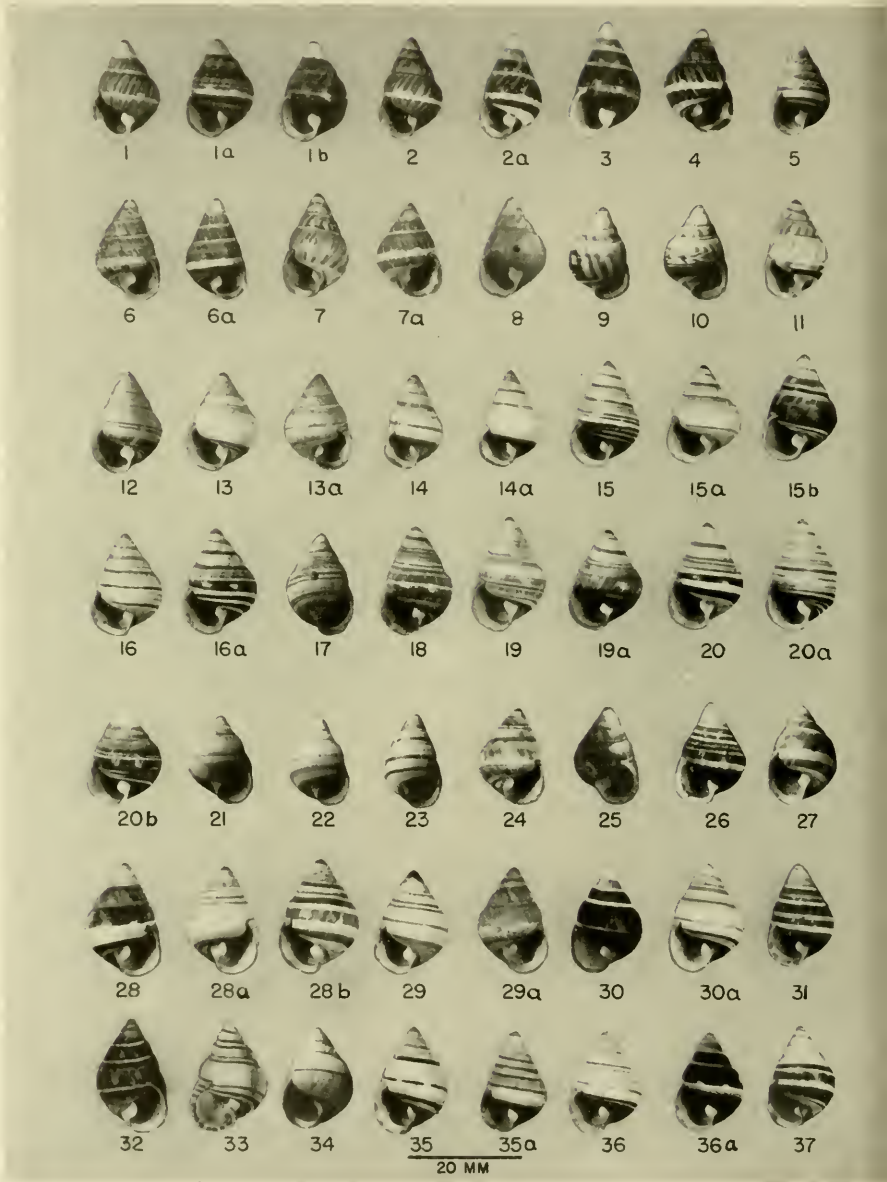
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SUBSPECIES OF *ACHATINELLA APEXFULVA*
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SUBSPECIES OF *ACHATINELLA APEXFULVA*
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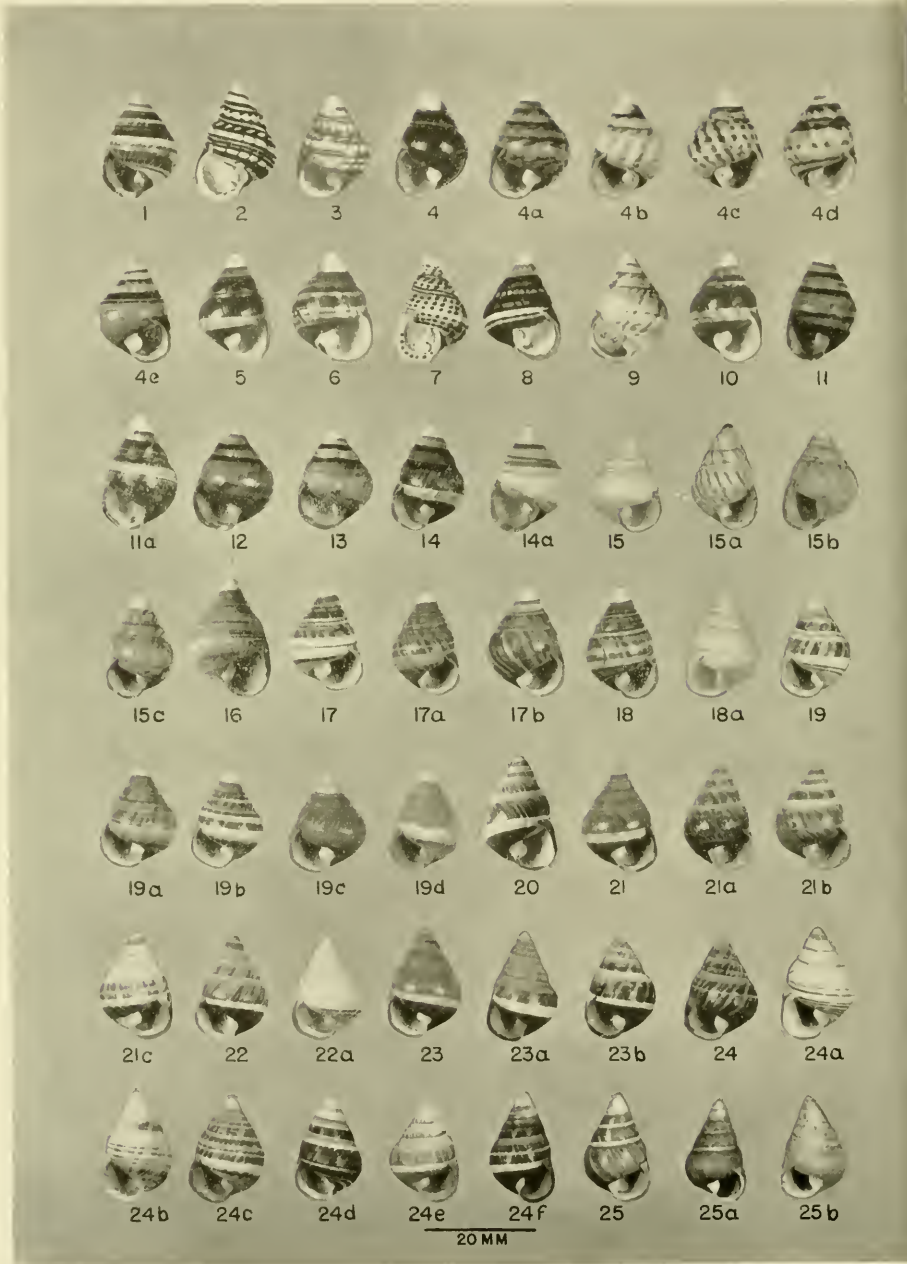
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SUBSPECIES OF *ACHATINELLA APEXFULVA*

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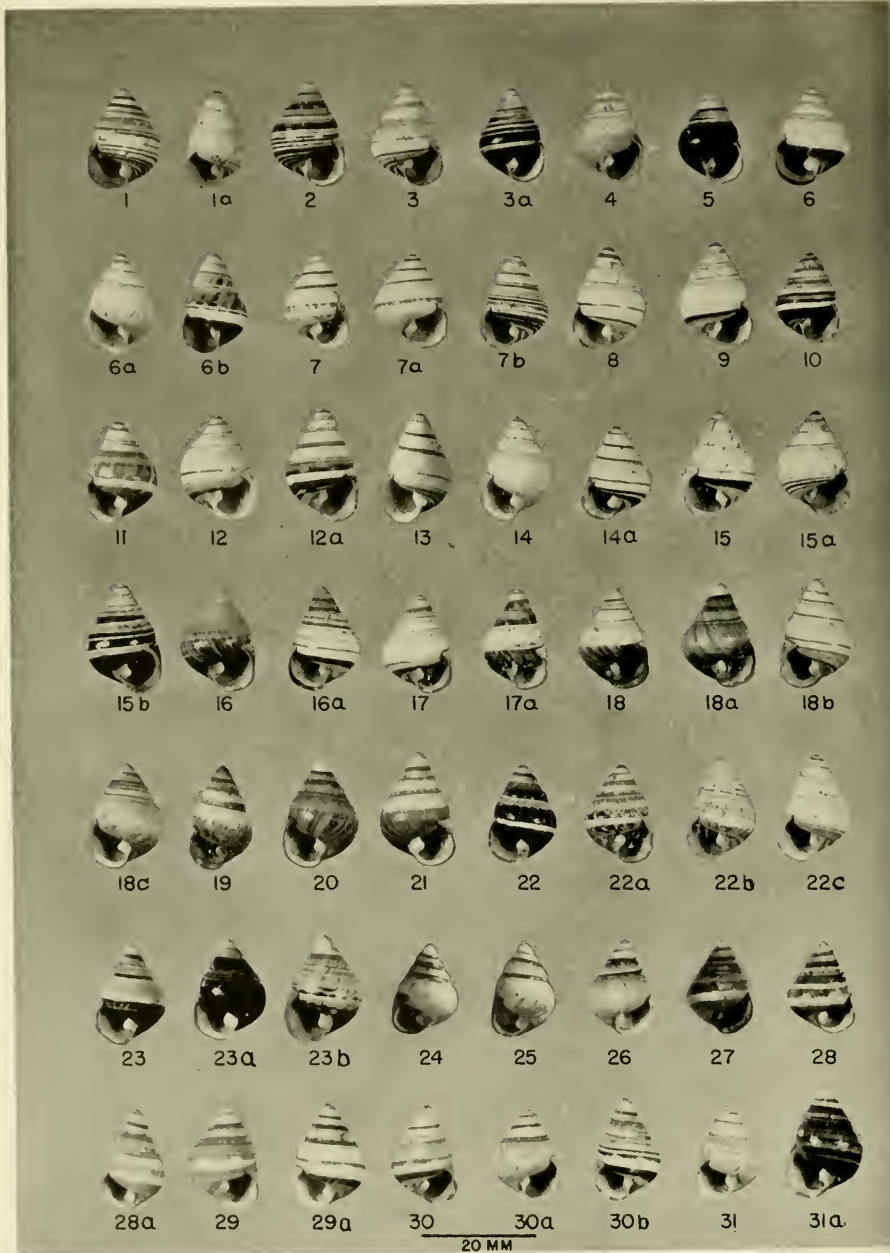
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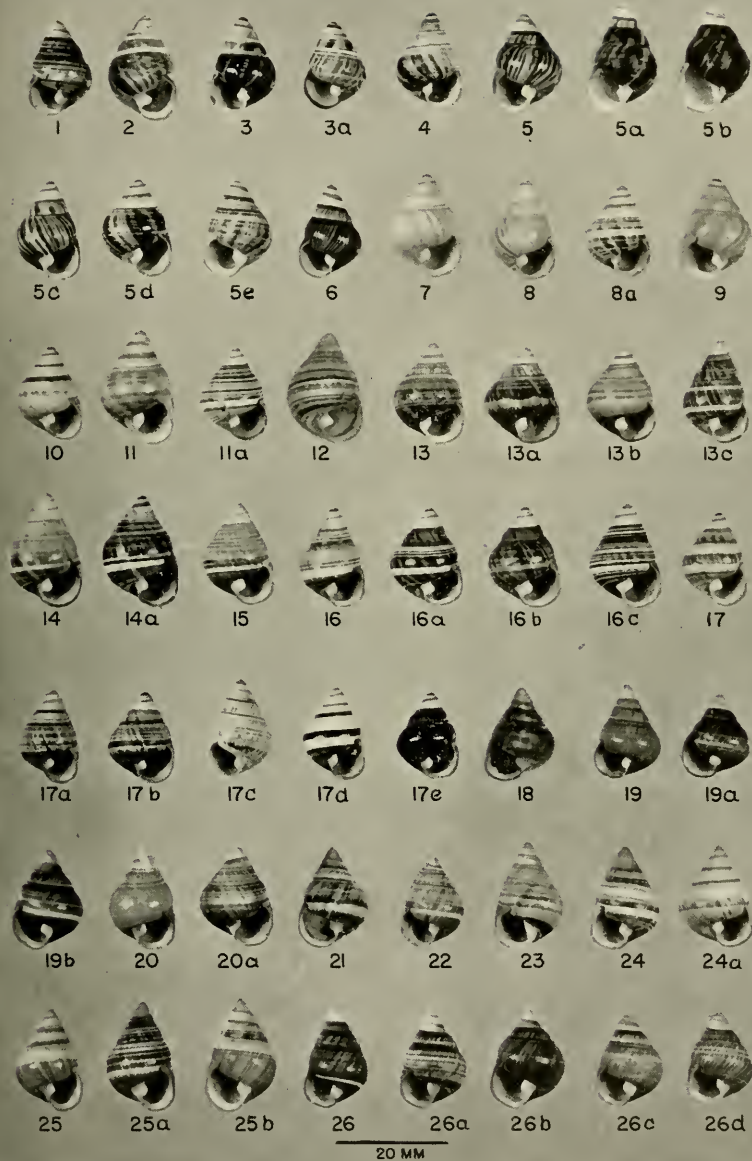


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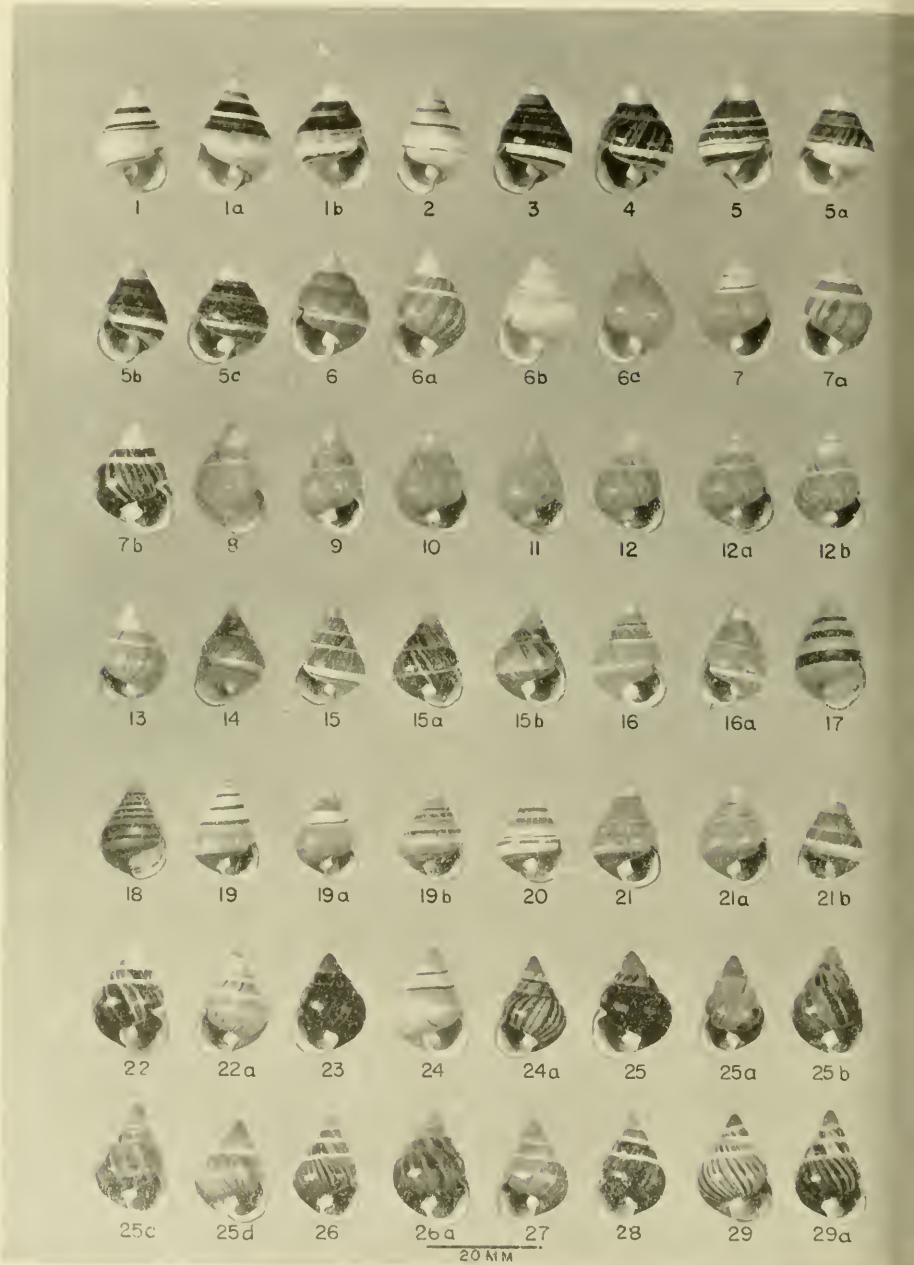
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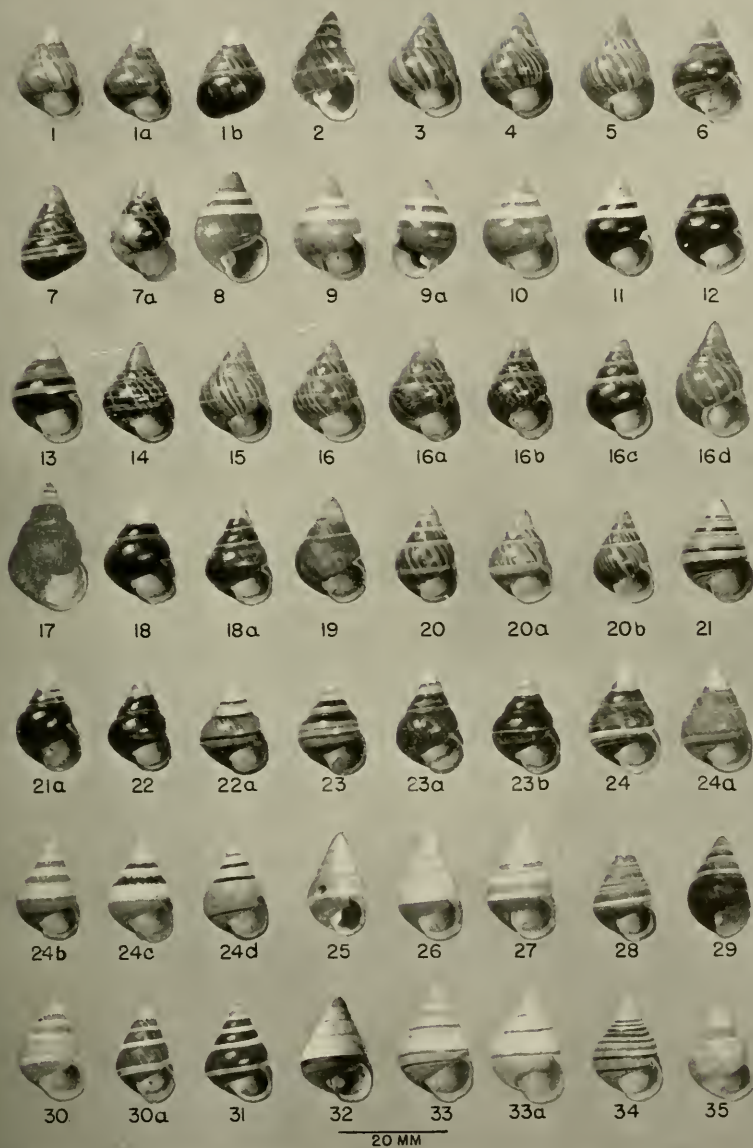
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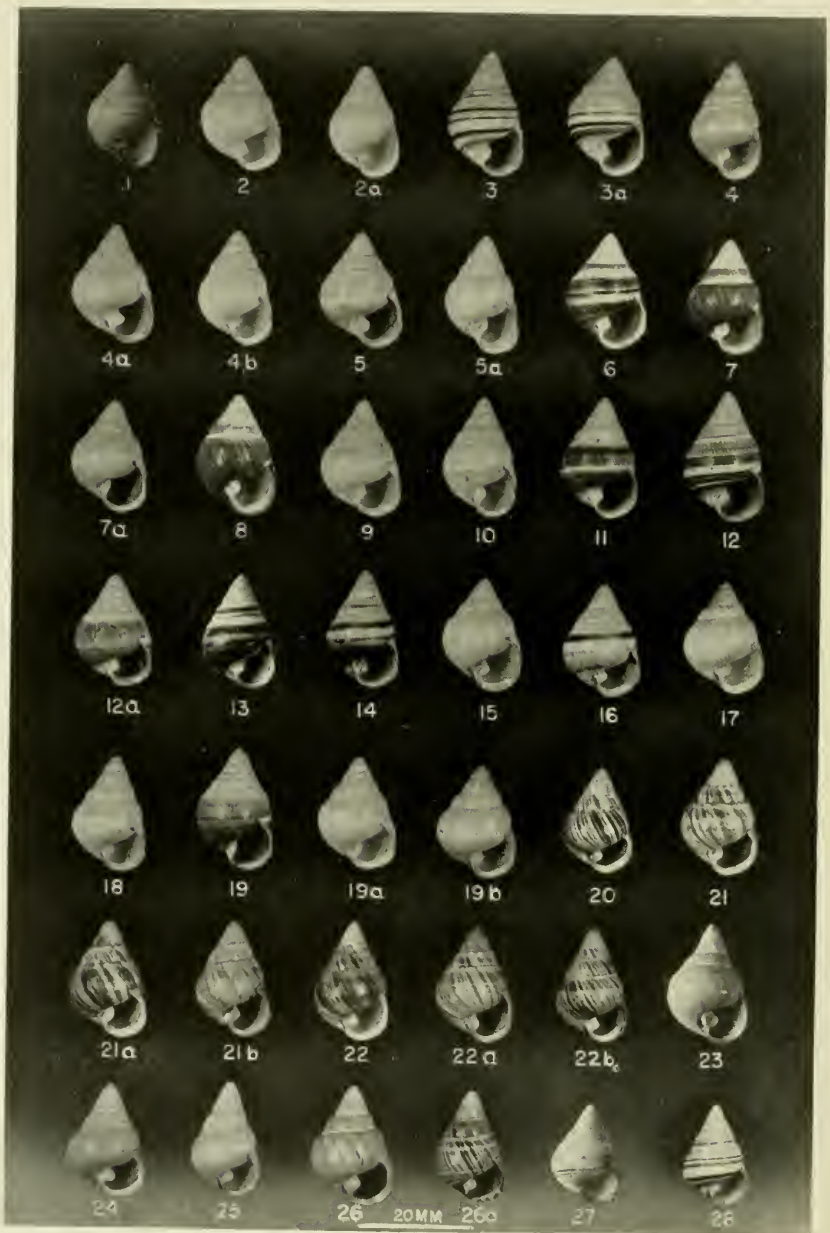


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