

Mr. Stearns submitted the following communication for Dr. Cooper:

On the Law of Variation in the banded California Land Shells.

BY J. G. COOPER, M. D.

I. ARIONTA Leach.

In studying further the species referable to this genus in California, together with their geographical distribution, some curious generalizations are arrived at, hinted at in a former article by me in the American Journal of Conchology, Vol. IV, p. 211, but not then so fully understood.

The close relationship and probable identity of some assumed species has been long apparent to all who have examined them, but from paucity of specimens, or reasons by which to account for their differences, they have been allowed to retain their rank as species until more numerous intermediate forms should establish their position as varieties.*

Though these connecting links are very few, and from the peculiarly local distribution of the chief forms are not likely to be found numerous, yet I think it can be shown that these local forms are not entitled to higher rank than that of sub-species which have had a common origin. By gradual divergence from one or a few centers of distribution, and being brought under the influence of different climates, they have assumed their present conditions, which are still subject to many variations, showing a tendency to the production of other forms. The systematic arrangement of these species and varieties, or sub-species, in connection with their distribution, can be best shown by a diagram. See Plate VII.

The plan here given shows the position and extent of range of each form allied to *Arionta*, the range north and south being shown by the parallels of latitude, and that east and west by the length of the brackets enclosing or adjoining the names, which may be compared with the scale given. It will be observed that the additions to our knowledge of their range has not much increased since the publication of the map given in the Amer. Jour. of Conch., Vol. IV, p. 211, though some doubtful points have been settled.

The chief centers of distribution are around San Francisco Bay, on the Santa Barbara islands, and near San Diego, whence one species follows up the Sierra Nevada to near lat. 40°. As this species has so wide a range, and presents nearly as many varieties as are found in the other groups, it becomes a question whether it is not the (Darwinian) progenitor of those along the coast which occupy regions of later geological age. Though the group around San Francisco Bay is one hundred miles distant from the nearest of that species, it must be remembered that the rivers all converge toward the bay, and that the floods

*Most of the names in use will no doubt be always retained for convenience in distinguishing between the various races, etc.

sometimes convert the entire interval into a lake, over which the species might have been spread, and since modified in its new localities. The chief argument to the contrary may be in the fact that no specimens are known to have been lately transported in this way. The most limited local varieties are indicated by names placed horizontally, and they usually differ more than others, being also more distant geographically.

As I have hinted at the probability of *A. tudiculata* being the progenitor of the coast forms, I may remark that the fossil form found at the foot of the Sierra Nevada, by Mr. Gabb, has the very high imperforate character of specimens now living close to the coast, and may have existed in the Miocene epoch when the San Joaquin valley was an arm of the sea, in which lived the sharks, etc., whose remains now abound not far from the Helix locality. It would then have lived close to the edge of this sea, and before the greater part of the coast range was elevated above it. The transplanting of the *Arionta* form to the latter may have been after the salt water was replaced by fresh, or in the Pliocene epoch.

Omitting for the present a critical comparison of the species and varieties which I have made ready for future publication, I intend here to point out only the geographical reasons for the conclusions to which I have arrived, as indicated in the diagram.

Around San Francisco Bay we have three well-marked, and always separable, species, viz: *arrosa*, *exarata*, and *Californiensis*, all living together on the west side, and at nearly equal distances north and south. Rare hybrids only exist as connecting links.

The last also extends to the east side of the bay, where it produces three varieties which mix together, and also with the typical form on the west side. *Var. nemorivaga* is almost equally common on both sides, and extends further south than any, there meeting (but not mixing) with *var. vineta*, at Monterey. (I omit "*Nickliniana*," as it seems founded upon a combination of the characters of these with *tudiculata*.)

Now, all these varieties of *Californiensis* follow certain definite rules in their divergence from the typical form, according to the amount of heat, moisture, fog, and wind they are subject to. *A. arrosa* and *exarata*, having only a narrow range close to the coast, are subjected to little difference in these conditions, and accordingly vary but little. *Californiensis* and varieties, on the contrary, spreading twice as far inland, gradually change from a high, imperforate form to depressed and umbilicate, as they pass into drier and hotter regions, with so many intermediate forms that their specific identity and the causes of variation can scarcely be doubted. A similar variation, but in less degree, occurs in the two others mentioned.

The next centre of distribution for *Arionta*, is that of *tudiculata* and varieties on the west slope of the Sierra Nevada, one hundred miles east of the preceding, and separated by wide alluvial valleys, in which no specimens of *any* species have ever been found.

This species presents a series of varieties analogous to those of *Californiensis*,

but much less extreme, and scarcely definable, as they run together very closely. This is a consequence of its distribution being continuous from north to south along a mountain range, and not interrupted by alternating mountains, valleys, and bays, as is that of the preceding. It is always recognisable by fixed characters permanent through great extremes of size.

At the south end of the range of *tudiculata* we meet with another species, in range somewhat intermingled with it, but always distinct, viz: *A. Kellettii* Fbs., which centres around San Diego Bay and the neighboring islands, from lat. 34° southward to lat. 28°, or perhaps 26°, in Lower California, four hundred or five hundred miles. The various forms found within this vast range, and which have been described as *Kellettii*, *redimita*, *Tryoni*, *intercisa*, *crebristriata*, and *Stearnsiana*, pass so insensibly from one to another that they must be considered merely varieties analogous to those of *Californiensis*. The most northern is the most different from the type which was from the most southern part of their range, but intermediate forms connect them all.

The parallel between the varieties of the two species is well shown by the following table :

A. Form elevated, imperforate. Inhabit cool, foggy exposures.

<i>b. vincta</i> Val.....	<i>Tryoni</i> Newc.
<i>c. nemorwaga</i> Val.....	<i>redimita</i> W. G. B.
<i>a. CALIFORNIENSIS</i> Lea.....	<i>KELLETTII</i> Fbs.

B. More depressed, perforate. From warmer localities.

<i>d. ramentosa</i> Gld.....	<i>crebristriata</i> Newc.
<i>e. reticulata</i> Pf.....	<i>intercisa</i> Newc.
<i>f. Bridgesii</i> Newc.....	<i>Stearnsiana</i> Gabb.

Though of course not strictly parallel, many points of resemblance can be seen between the forms thus compared. Thus the varieties *d.* and *e.* of each have similar relations *inter se* as to sculpture, while *f* is in each very similar to the type; the "circular" arrangement being well represented in each group.

All these banded species and varieties are connected so closely together by their banded character, that a common origin in the dim periods of the past seems highly probable, and yet their parallelism with another large series existing in the same regions, but always distinguishable, indicates that some common physiological law, still unknown, is connected with this character. In the form of shell and animal, as well as in its anatomy, they seem more closely connected with the Lower Californian group embracing *areolata*, *Pandoræ*, *levis*, etc., which vary from colorless to many-banded or blotched, showing a relationship similar to that held by "*Arionta candidissima*" of Palestine to *A. arbustorum* of Europe, a species between *Californiensis* and *Kellettii*.

II. LYSINOE H. and *A. Adams*.

A comparison of the distribution of the species which I have referred to this group with that of the *Ariontas*, presents one very striking difference at first

view, namely, that the former do not occur in localized groups widely separated, but in linear series following the mountain ranges from north to south, or the chains of islands either in the same or the opposite direction. As with *Arionta*, however, a few isolated forms occur like extreme local developments of varieties, perhaps depending for their characters on local influences, though these are not always so easily understood. See Plate VIII.

Two new elements of specific distinction also occur, viz: angulation of the periphery, and more or less pilosity of the epidermis.*

I have before pointed out the apparent relation between angulation and shaly mountains, as well as between pilosity and arid climate. Though connecting links are not known between the forms showing these characters, and their nearest allies without them, (except in the case of *infumata* and *fidelis*) I am now decidedly of the opinion that they will be found between *Mormonum* and *Hillebrandi* (being already imperfectly indicated), and between *Dupetithouarsi* and *sequoicola*.† Three of these therefore will have to take rank as varieties of the others, and more such instances will doubtless occur. There is some evidence that *L. Mormonum* was the geological progenitor of the forms living near the coast, in the fact that a variety, nearly intermediate between it and *fidelis*, occurs at the Dalles of the Columbia, where *fidelis* passes eastward through the gap of the Cascade mountains. Some varieties also approach quite near *L. Traskii*, which meets it southward.

The varieties of the species of this group, corresponding to *a, b, c*, etc., of the former, are not so distinctly marked, and have not received so many distinctive names, except in the following cases:

<i>b. AYRESIANA</i> Newc.....	<i>REMONDII</i> Tryon.
<i>c. DUPETITHOUARSI</i> Val.....	<i>rufocincta</i> Newc.
<i>a. FIDELIS</i> Gray.....	<i>TRASKII</i> Newc.
<i>d. infumata</i> Gld.....	<i>ROWELLII</i> Newc.
<i>e. MORMONUM</i> Pf.....	<i>Lohrii</i> Gabb.
<i>f. sequoicola</i> Cp.....	<i>Gabbii</i> Newc.

Those best entitled to specific rank being in capitals, it appears that the divergences of these forms are greater than in the former case.

The groups *d* and *e* are mostly flattened, angulated, and hirsute, at least when young, while *f*, as before, returns by the "circular" method toward the characters of *b*.

No certain instances of specific intergradation between members of *Lysinoe* and *Arionta* are known. Though I formerly supposed some varieties to be intermediate, or hybrids, I am now inclined to consider them instances of mimetic resemblance, as species of one group are well known to approach those of another where their geographical limits approach each other. We find, however,

**L. Traskii*, as well as the allied forms, is hirsute up to the size of three or four whorls in Ventura county.

† Mr. G. W. Dunn has lately found specimens of *sequoicola* very black and without band, though not angled like *infumata*. Hab., north of Santa Cruz.

members of each living together in numerous localities throughout the range of both, without intermediate forms.

THE LAW OF VARIATION.

The biological law deducible from the preceding facts is, that those species, sub-species, and varieties living in cool, damp situations, become more highly developed (but not always larger) than the others, the shell assuming a more compact (imperforate) form, and losing those indications of immaturity referred to, viz : sharp, delicate sculpture, bristles, and angular periphery.

These characteristics, however, remain more or less permanently for indefinite periods, and give that fixedness to the various forms, even when living under the same conditions, which enables us to retain them as *sub-species*, differing from *varieties* in permanency, and from *races* in not inhabiting distinct regions. *Arionta arrosa* and *Lysinoe Dupetithouarsi* are thus the highest developed of either group in California.

The President informed the Academy that Mr. C. E. Watkins, the well-known photographer, had generously offered to make photographs, cabinet size, of all the members, and present a copy of each to the Academy, provided that they would furnish a suitable album for their preservation.

REGULAR MEETING, JULY 21ST, 1873.

President in the Chair.

Thirty-six members present.

Dr. J. C. Horner de Tavel, of Oakland, and A. Gros, were elected resident members, and H. H. Moore and D. O. Mills, life members.

Donations to Library : Société des Arts et des Sciences of Batavia, Verhandelingen, Vol. XXXIV et XXXV; Tijdschrift XVIII, 1, 2, 3, XX, 1, 2; Notulen VIII, 3, 4, IX, 1871. Beitrag zur Kenntniss der Insekten-Fauna des Kantons Zürich; Käfer von Kaspar Dietrich; 4to., Zürich, 1865; from H. Erni, U. S. Consul. The Principle of Least Action in Nature, etc., etc., by the Rev. Samuel Haughton, pamph. 8vo., London, 1871; from the author. R. Comitato Geologico d'Italia, Nov. and Dec., 1872, Jan. and Feb., 1873. Rapport sur les Progres recents des Sciences Zoologiques en France, par M.