OCCASIONAL PAPERS

OF THE

California Academy of Sciences

No. 75, 6 pages, 2 tables. October 22, 1969

# Early Records of the Barnacle *Balanus improvisus* Darwin from the Pacific Coast of North America

By

James T. Carlton and Victor A. Zullo

*California Academy of Sciences, San Francisco, California 94118*

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1969

OCCASIONAL PAPERS
OF THE
CALIFORNIA ACADEMY OF SCIENCES

No. 75, 6 pages, 2 tables. October 22, 1969

# Early Records of the Barnacle *Balanus improvisus* Darwin from the Pacific Coast of North America

By
James T. Carlton and Victor A. Zullo
*California Academy of Sciences, San Francisco, California 94118*

*Balanus improvisus* Darwin is commonly encountered in the Atlantic and Caribbean littoral, and has been reported from various localities in the Mediterranean, Red Sea, and Indian Ocean. Although a euryhaline species, it is usually found in estuarine environments in association with oysters and other molluscs tolerant of lowered salinities.

The distribution of *B. improvisus* in the Pacific Ocean is spotty, however, and is considered to be the result of human introduction (Kawahara, 1963; Matsui and others, 1964; Newman, 1967). This species was first reported from the Pacific Coast of North America by Rogers (1939) who discovered it in San Francisco Bay, California (see Henry, 1942, table; 1959, p. 200). Since 1939, *B. improvisus* has been reported from Tomales Bay, Marin County, and the Salinas River estuary, Monterey County, both in California, and from the Columbia River in Oregon, these in addition to further records from greater San Francisco Bay (table 1). At present this species is well established in estuarine parts of San Francisco Bay and occurs up into rivers and creeks feeding the Bay, where salinities are negligible for most of the year.

There is little doubt that *B. improvisus* was introduced by man to California. Examination of late Cenozoic barnacle faunas from numerous Pacific Coast localities, including a late Pleistocene oyster-barnacle assemblage at Rodeo, California (University of California Museum of Paleontology, Berkeley locality A-3150), has failed to uncover specimens of *B. improvisus*. Newman (1954) also noted the absence of this species in Indian mound material at Brooks Island, San Francisco Bay, although *B. glandula* Darwin was common on mollusc shells now frequented by *B. improvisus*.

Table 1. *Records of* Balanus improvisus *from the Pacific Coast in the literature (1939–1968).*

| Date | Locality | Authority |
|---|---|---|
| 1939 | San Francisco Bay, including San Pablo Bay and upper reaches of Suisun Bay | Rogers (1939, 1949), Henry (1942, 1959) |
| 1939 | "Inlets to flood valves on naval vessels cruising on the east and west coasts of the United States" | Henry (1942) |
| 1940–1942 | Oakland estuary, San Francisco Bay | Graham and Gay (1945) |
| 1952 | Lake Merritt, Oakland, San Francisco Bay | Marchette (1953) |
| 1952 | San Pablo and Suisun Bays, (greater San Francisco Bay) | Filice (1954, 1959a, 1959b) |
| 1953 | San Francisco Bay; mouth of Salinas River, Monterey County | Newman (1954, 1967) |
| 1957 | Astoria, Oregon (Youngs Bay and Youngs River, lower Columbia River system), on crayfish, *Pacifastacus trowbridgii* | Miller (1965) |
| 1959 | Tomales Bay, Marin County | Johnson and Juskevice (1965) |

The question remains, however, as to how and when this barnacle was introduced. *Balanus improvisus* is a common fouling barnacle on ships in the Atlantic Ocean, and San Francisco Bay has been a major port of call for vessels from the East Coast of North America since the gold rush of 1849. During the peak years of the California gold rush, ships not only docked in the Bay, but were abandoned by the hundreds, thus greatly increasing the probability of the successful establishment of barnacles.

A second method, resulting from the importation of the East Coast oyster, *Crassostrea virginica* (Gmelin), is an even more likely candidate (see Skinner, 1962; Barrett, 1963 for discussion of the West Coast oyster industry). Both seed and adults of this species are known to have been introduced into San Francisco Bay for purposes of culture as early as 1869. Prior to this time, and as early as 1849, attempts were made to market live oysters in San Francisco, but most of these did not survive the journey across the Isthmus of Panama. Eastern seed oysters were shipped by rail in terms of hundreds of carloads per year until 1910, but adults, which were often held in beds in San Francisco and Tomales Bays until sold, continued to be imported. *Balanus improvisus* is often encountered as an epizooite of *Crassostrea virginica*, and would stand at least an equal chance with the oysters of surviving rail transportation from the East Coast. Assuming that shipping and oyster importation could both provide the

TABLE 2. *Early records of* Balanus improvisus *on the Pacific Coast (prior to 1939).*

| Date | Locality | Collector | Material |
|---|---|---|---|
| 1853 | UCMP 2394, San Francisco Bay | C. de Lange | 2, on *Mytilus edulis* (Linnaeus) |
| 1900 | SU 21481, San Mateo, San Francisco Bay | E. E. Smith | 1 live, 1 empty shell, on *Crassostrea virginica* |
| 20 October 1903 | CAS 41224, Cooley'sLanding, Alviso, Santa Clara County, San Francisco Bay | unknown | 2, 1 on *Modiolus demissus* (Dillwyn) |
| 1910–1915 | SU 4651, Redwood City estuary San Francisco Bay | H. Hannibal | 4, on *Mytilus edulis* |
| 3 April 1912 | CAS 41202, San Francisco Bay | E. C. Johnston (naturalist, *Albatross*) | 2, on *Mytilus edulis* |
| 27 November 1912 | CAS 41200, *Albatross* Station D-5812B, south San Francisco Bay, 1 fathom | (see Packard, 1918, p. 207) | common (dead), on *Crassostrea virginica* |
| October, 1913 | CAS 41201, Alameda, San Francisco Bay | "DSG" | 9, on valve of live *Ostrea lurida* Carpenter |
| 1 January 1922 | CAS 41189, Oakland Mole, Oakland, San Francisco Bay | E. L. Lazier | 3, from submerged timber 12 feet below low water |
| 28 August 1922 | CAS 41225, Dumbarton Bridge, south San Francisco Bay | (see Hill and Kofoid, 1927, loc. 57) | 3, from pilings; 1 with 12 egg cases of *Urosalpinx cinerea* (Say) |
| 1 August 1923 | CAS 41190, Crockett, San Pablo Bay | (see Hill and Kofoid, 1927, loc. 6) | numerous, some on *Mytilus edulis*, from submerged timbers |
| September, 1931 | CAS 27023, Rodeo, San Pablo Bay | G Dallas Hanna | 1, on *Mytilus edulis* |
| 24 March 1932 | CAS 41226, San Pedro outer harbor, berth 59, opposite column 43 | E. L. Lazier | numerous, on creosoted fender pile, 4 feet above low water |
| 1934 | SU 3814, Palo Alto Yacht Harbor, San Francisco Bay | Stanford Class | numerous, on *Ostrea lurida* |
| no date (locality registered in 1955) | UCMP B-1273, Willapa Bay, Washington | T. Kincaid | numerous, on *Crassostrea gigas* (Thunberg) |

means for establishing *Balanus improvisus* in San Francisco Bay, it is probable that this barnacle was successfully introduced on numerous occasions.

In investigating the possibilities of introductions prior to 1939, a search was made of the following collections from San Francisco Bay and other Pacific Coast localities:

1) California Academy of Sciences (CAS)
   a) Recent dry mollusc collection, Department of Geology.
   b) Wet mollusc collection, Department of Invertebrate Zoology.
   c) *Albatross* dredgings from San Francisco Bay, 1912–1913.
   d) San Francisco Bay marine boring study samples, San Francisco Bay marine piling committee, 1920–1924.
2) University of California Museum of Paleontology, Berkeley (UCMP), recent mollusc collection.
3) Stanford University (SU), recent mollusc collection.
4) San Francisco Maritime Museum, artifact collection.

The results of this survey are presented in table 2. *Balanus improvisus* was discovered in 14 collections made between 1853 and 1934. All of the listed records are based on specimens having opercular valves. With the exception of the *Albatross* collection of 27 November 1912, the San Mateo collection of 1900, the Alviso collection of 20 October 1903, and the undated material from Willapa Bay, Washington, all of the barnacles were collected alive on either native molluscs or pilings, thus indicating at least temporarily successful establishment.

*Balanus improvisus* is represented in every decade of the twentieth century. The samples collected in 1903 from Alviso and 1913 from Alameda coincide closely with sites of commercial *Crassostrea* beds that were under cultivation prior to 1915 (Skinner, 1962, pl. 3). Only a single nineteenth century record was obtained. The lack of additional early material is in large part the result of the dearth of adequately dated and localized collections. However, the 1853 record based on C. de Lange's collection appears authentic, and is in keeping with our knowledge of his activities during the middle nineteenth century. As this record precedes oyster culture activities, it is possible that the specimens represent an early introduction by shipping.

In addition to the specimens from San Francisco Bay, a well documented lot collected in 1932 from San Pedro harbor, California and an undated series on *Crassostrea gigas* from Willapa Bay, Washington were uncovered. Whether *B. improvisus* presently occurs in these regions is not known.

*Balanus amphitrite amphitrite* Darwin (also known as *B. a. denticulata* Broch, *B. a. franciscanus* Rogers, *B. a. hawaiiensis* Broch, and *B. a. herzi* Rogers) is another introduced barnacle that is presently well established in San Francisco Bay and various localities in southern California. Rogers (1939) is also responsible for first noting its occurrence on the Pacific Coast. A search was made

for earlier occurrences of this barnacle as well, but no specimens were discovered.

The absence of *B. a. amphitrite* in earlier collections, if real, probably reflects its absence on the Atlantic Coast of North America prior to World War I, and perhaps as late as World War II (Zullo, 1966, pp. 233–235). Since its introduction to the East Coast, this barnacle has become a major element of the intertidal fauna south of Cape Hatteras, North Carolina and is often found on oysters in association with *B. improvisus*. Had it been available for transport from the East Coast, its history of introduction would probably have paralleled that of *B. improvisus*.

ACKNOWLEDGMENTS

We wish to extend our thanks to Dr. Leo G. Hertlein and Dr. Robert C. Miller, California Academy of Sciences; Dr. A. Myra Keen, Stanford University; Mr. Joseph H. Peck, Jr., University of California, Berkeley; Dr. Edmund H. Smith, Pacific Marine Station, University of the Pacific; and Mr. Harlan Soeten, San Francisco Maritime Museum for their help in obtaining the materials used in this study.

REFERENCES CITED

BARRETT, ELINORE M.

1963. The California oyster industry. The Resources Agency of California. Department of Fish and Game, Fish Bulletin 123, pp. 1–103, figs. 1–32.

FILICE, F. P.

1954. An ecological survey of the Castro Creek area in San Pablo Bay. The Wasmann Journal of Biology, vol. 12, no. 1, pp. 1–24, figs. 1–3.

1959a. Invertebrates from the estuarine portion of San Francisco Bay and some factors influencing their distributions. The Wasmann Journal of Biology, vol. 16, no. 2, pp. 159–211, figs. 1–3.

1959b. The effect of wastes on the distribution of bottom invertebrates in the San Francisco Bay estuary. The Wasmann Journal of Biology, vol. 17, no. 1, pp. 1–17, fig. 1.

GRAHAM, H. W., AND H. GAY

1945. Season of attachment and growth of sedentary marine organisms at Oakland, California. Ecology, vol. 26, no. 4, pp. 375–386, figs. 1–9.

HENRY, DORA P.

1942. Studies on the sessile Cirripedia of the Pacific Coast of North America. University of Washington Publications in Oceanography, vol. 4, no. 3, pp. 95–134, pls. 1–4, figs. 1–5.

1959. The distribution of the *amphitrite* series of *Balanus* in North American waters, *in* Marine boring and fouling organisms (edited by D. L. Ray). University of Washington Press, Seattle, Washington, pp. 190–203, pls. 1–4.

HILL, C.L., AND C. A. KOFOID, editors-in-chief

1927. Marine borers and their relation to marine construction on the Pacific Coast. Final report of the San Francisco Bay Marine Piling Committee, San Francisco, California, pp. ix + 357, 143 figs.

JOHNSON, R. G., AND J. A. JUSKEVICE

1965. Check list of marine invertebrates of the Tomales Bay region, Marin County, California. Pacific Marine Station (University of the Pacific), Research Report no. 5, pp. 1–78.

Kawahara, T.

1963. Invasion into Japanese waters by the European barnacle *Balanus improvisus* Darwin. Nature, vol. 198, no. 4877, p. 301, fig. 1.

Marchette, N. J.

1953. A limnological study of a brackish water lake. Unpublished Master's thesis, Department of Zoology, University of California, Berkeley, iii + 96 pp.

Matsui, T., G. Shane, and W. Newman

1964. On *Balanus eburneus* Gould (Cirripedia, Thoracica) in Hawaii. Crustaceana, vol. 7, pt. 2, pp. 141–145, fig. 1.

Miller, C.

1965. Western North American crawfishes *Pacifastacus* in brackish water environments. Research Briefs, Fish Commission of Oregon, vol. 11, no. 1, pp. 42–50, figs. 1–2.

Newman, W. A.

1954. Some ecological considerations on barnacles of the San Francisco Bay estuarine system. Unpublished Master's thesis, Department of Zoology, University of California, Berkeley, ii + 117 pp.

1967. On physiology and behavior of estuarine barnacles. Proceedings of Symposium on Crustacea, Marine Biological Association of India, pt. 3, pp. 1038–1066, figs. 1–9.

Packard, E. L.

1918. Molluscan fauna from San Francisco Bay. University of California Publications in Zoology, vol. 14, no. 2, pp. 199–452, pls. 14–60.

Rogers, F. L.

1939. Notes on barnacles of the San Francisco Bay region. Unpublished paper read before the Sixth Pacific Science Congress.

1949. Three new subspecies of *Balanus amphitrite* from California. Journal of Entomology and Zoology, vol. 41, no. 2, pp. 23–32, pl. 1.

Skinner, John E.

1962. An historical review of the fish and wildlife resources of the San Francisco Bay Area. The Resources Agency of California. Department of Fish and Game, Water Projects Branch Report no. 1, pp. 1–226, figs. 1–50, pls. 1–9.

Zullo, V. A.

1966. Thoracic Cirripedia from the continental shelf off South Carolina, U. S. A. Crustaceana, vol. 11, pt. 3, pp. 229–244, figs. 1–7.