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EXTINCT OR EXTANT? A NEW SPECIES OF INTERTIDAL BEMBIDIINE (COLEOPTERA: CARABIDAE: BEMBIDIINI) FROM THE PALOS VERDES PENINSULA, CALIFORNIA

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ABSTRACT

A new species of bembidiine carabid beetle, *Bembidion palosverdes,* is described from the Palos Verdes Peninsula, Los Angeles County, California (type locality: Point Vicente), based on museum specimens collected 27 years ago. This species is apparently restricted to the rocky intertidal habitat on the peninsula. It is tentatively placed in the *laterale* species group, with *Bembidion laterale* from coastal western Europe and North Africa, and is the only species of *Bembidion* in North America known to occur in the rocky intertidal habitat. Failure of recent efforts to find living representatives of this species at its only known localities prompts concern for its present status, as discussed in relation to pertinent conservation issues.

This paper addresses the severely disturbed southern coast of California, near where the Santa Barbara oil spill of January 28, 1969 wreaked havoc on shore life (Evans 1970). We describe a new species of beetle that may already be extinct—extinguished perhaps by that same or some other less newsworthy oil spill—before it was even known to science. The type series of specimens was discovered during our routine sorting of undetermined specimens in the collection of the California Academy of Sciences. Having collected *Bembidion,* the genus to which this particular species belongs, extensively throughout North and Middle America and Europe and studied its species for more than a decade, we present a preliminary hypothesis of its genealogical (phylogenetic) relationship within that genus and its restricted role in the coastal environment, and discuss uncertainty with regard to its present status.

MATERIALS AND METHODS

All known specimens of this new species were studied and are listed below. We also studied and compared specimens of several other Pacific Rim and European intertidal *Bembidion* species (see also Erwin and Kavanaugh 1980), including *B. laterale* Samouelle, *B. laticeps* LeConte, *B. nigropiceum* Marsham, and *B. yokohamae* Bates.

Methods, descriptive terms, and criteria for taxonomic ranking follow those previously detailed by us (Erwin and Kavanaugh 1981). Features listed in the diagnosis for the new species are not repeated in the description. The only

measurement provided is for standardized body length: the sum of fixed measurements along midline of head (from apical margin of clypeus to posterior margin of left compound eye), pronotum (from apical to basal margin), and elytron (from apex of scutellum to apex of longer elytron). Illustrations were made with the aid of drawing tubes on a Wild M5 stereoscopic dissecting microscope and a Nikon P6-SKE stereoscopic compound microscope. The habitus drawing (Fig. 1) was produced using a Macintosh computer and Adobe Illustrator software by enhancement of a scanned drawing made with a drawing tube (see also Kavanaugh and Erwin 1991).

Bembidion palosverdes Kavanaugh and Erwin, **new species**
(Palos Verdes intertidal minute carabid beetle)

HOLOTYPE: Male, in the California Academy of Sciences (CAS), labeled "Vicente PT L.A. CO. CALIF. 6-64"/"D. GIULIANI COLLECTOR"/"Derham Giuliani Collection California Academy of Sciences 1967"/"HOLOTYPE Bembidion palosverdes Kavanaugh and Erwin 1992". PARATYPES: One male, same data as holotype, in CAS; three males and two females, labeled "PT. FERMIN L.A. CO. CALIF. 6-64"/"D. GIULIANI COLLECTOR", one male in the United States National Museum of Natural History, the remaining four paratypes in CAS.

TYPE LOCALITY.—Point Vicente, Los Angeles County, California.

DIAGNOSIS.—Head with frons and vertex impunctate, frontal furrows parallel, not extended anteriorly onto clypeus; eye size moderate, longitudinal diameter much greater than length of scape; maxillary palpus with length of terminal palpomere less than 0.25 times length of penultimate palpomere; pronotum narrow, markedly narrowed basally, basal angles clearly defined, subrectangular or slightly obtuse, basal margin sinuate laterally; elytron uniformly rufopiceous (without maculae), humerus undefined, lateral elytral margin arcuately sloped to near scutellum, lateral margination abruptly ended anteriorly at humeral region, seven interneurs present although interneurs 1 to 5 faintly impressed, intervals smooth, impunctate, evenly microsculptured throughout, interval 3 with three moderately foveate discal setiferous punctures, all foveae confluent with interneur 3, interval 6 markedly costate in apical half; hindwings absent; abdominal sterna each with one pair of paramedial setae in both sexes; restricted to intertidal zone, Pacific coast of southern California.

DESCRIPTION OF FORM AND STRUCTURE.—Size very small, standardized body length of male 2.3–2.5 mm, of female 2.3 mm. Form (Fig. 1) with head large, pronotum narrow, and elytra proportionately short. *Color:* Head, pronotum, venter (except abdominal sterna), and all appendages rufous or rufotestaceous; elytra rufopiceous, with lateral margin and interval 1 slightly paler in some individuals; abdominal sterna (at least apically) rufopiceous. *Luster:* Head slightly shiny medially, otherwise entire dorsal surface dull in both sexes; ventral surfaces moderately shiny. *Microsculpture:* Entire dorsal surface with isodiametric meshes, well impressed throughout in both sexes, but least impressed medially on frons and vertex and most deeply impressed on elytra; abdominal sterna with meshes transverse, about twice as wide as long.

Head: Large, smooth and convex dorsally, broad and robust posterior to eyes, frontal furrows shallow and broad; antennae short and stout, antennomeres submoniliform, scape with one anteroapical seta, pedicel with apical whorl of setae only, antennomeres 3 to 11 covered with dense, short setae in addition to apical whorl; labrum with three pairs (two paramedial and one lateral) of apical setae; clypeus with one pair of midlateral setae; mandibles porrect, moderately long, with apex curved medially as a sharp tooth;

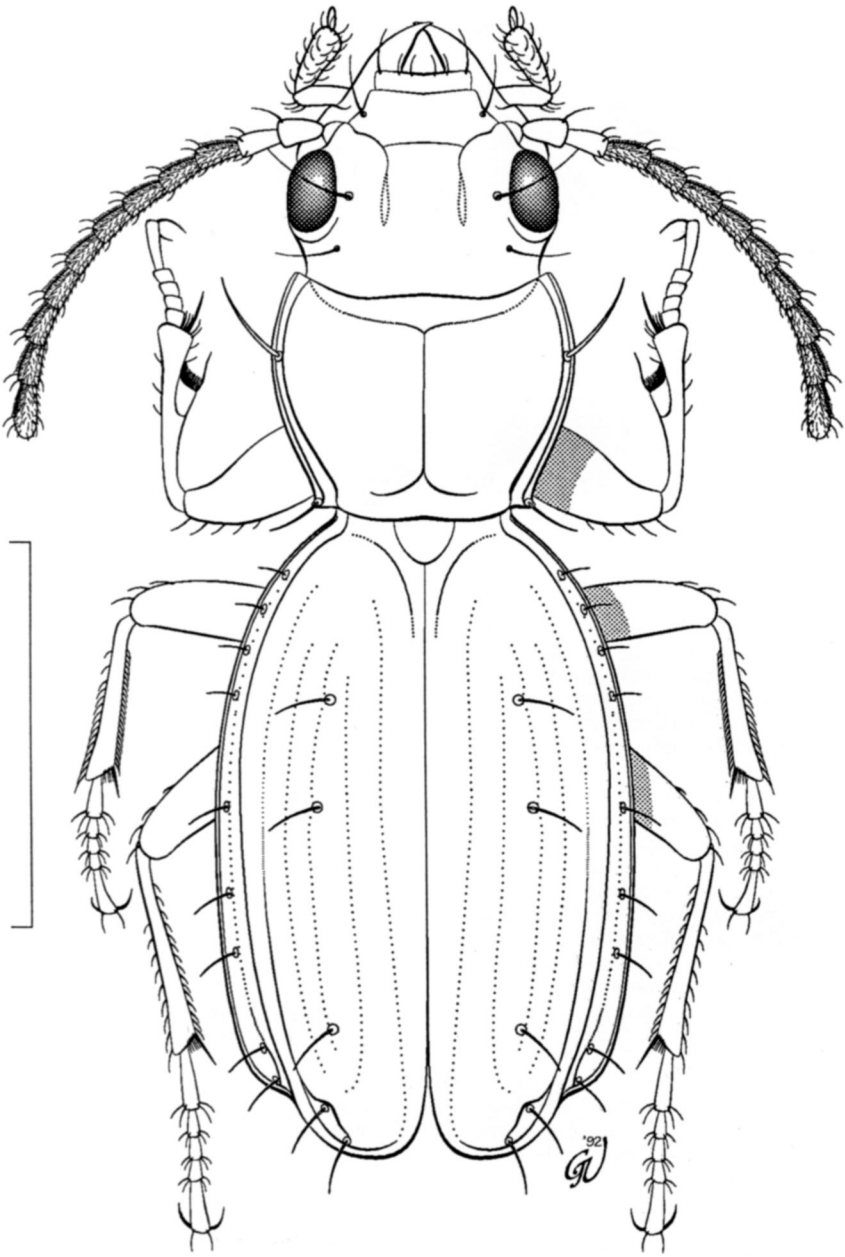


Fig. 1. Habitus, dorsal aspect, *Bembidion palosverdes*, n. sp. Scale line = 1.0 mm.

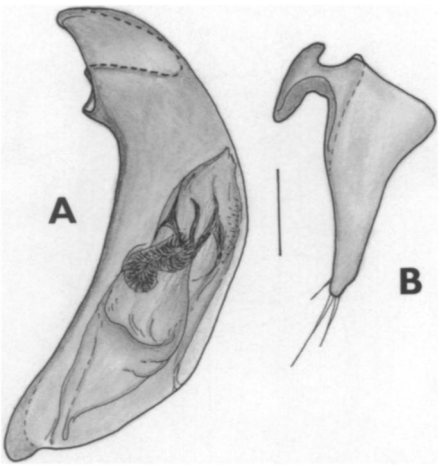


Fig. 2. *B. palosverdes,* n. sp., male genitalia. A, median lobe, left lateral aspect; B, left paramere, lateral aspect. Scale line = 0.1 mm.

maxillary and labial palpi short, penultimate palpomeres broadened subapically; mentum with a large tooth apicomedially.

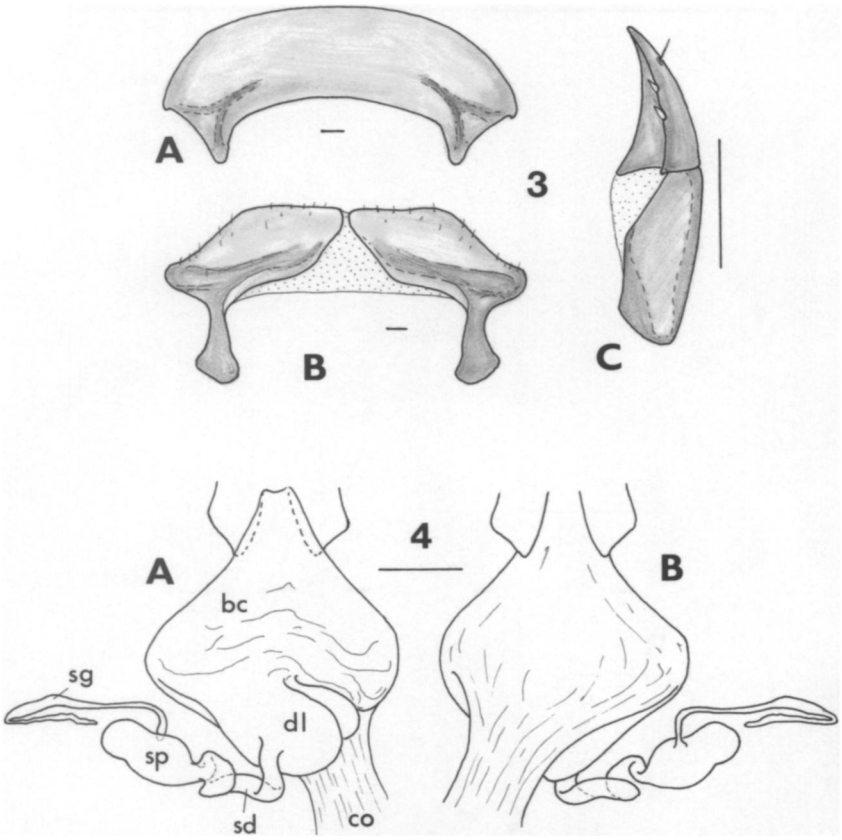
Prothorax: Pronotum with greatest width slightly anterior to middle; disc moderately convex, smooth, without evident macrosculpture; apical margin straight or very slightly concave; lateral margin slightly and evenly arcuate anterior to short, moderately deep basolateral sinuation; basal margin distinctly sinuate laterally and straight medially; apical angles short, narrow, narrowly rounded apically; apical margination absent; lateral bead narrow but clearly defined throughout; basal margination absent; lateral explanation narrow throughout; anterior transverse impression shallow or absent; median longitudinal and posterior transverse impressions deeply and narrowly impressed; laterobasal foveae smooth, short, deep, not extended anteriorly onto disc, confluent anteriorly with lateral explanation; laterobasal carinae absent; midlateral setiferous puncture present anterior to middle; basolateral setiferous puncture present at basal angle. Prosternal intercoxal process unmargined.

Pterothorax: Elytra moderately flat, with silhouette ovoid, widest slightly posterior to middle, subapical lateral sinuation very deep; intervals flat or very slightly convex; interval 5 with two setiferous punctures apically; umbilicate series of setiferous punctures on interval 7 divided into anterior, middle, and posterior groups of four, two or three, and two setae, respectively. Metathorax shortened, metepisternum with length of lateral margin equal to 1.3 times length of anterior margin; metasternal intercoxal process entirely unmargined.

Legs: All legs relatively short for *Bembidion*; front tarsomeres 1 to 3 expanded laterally and tarsomeres 1 and 2 with small pads of adhesive hairs ventrally in males, all tarsomeres narrow and without pads of adhesive hairs in females.

Male genitalia: Median lobe (Fig. 2A) with apex broadly rounded, slightly recurved dorsally; shaft moderately broad, narrowed distal to basal bulb, ventral margin slightly and evenly concave in lateral aspect; internal sac complex, BW large and sigmoid, CH1 absent, CH2, CH3, CH4, and CH5 long and styliform, small microtrichial field dorsally near apex of sac. Left paramere as in Figure 2B.

Female genitalia: Eighth tergum as in Figure 3A; eighth sternum as in Figure 3B; ovipositor (Fig. 3C) with gonocoxite moderately long and slender, asetose, gonostylus moderately arcuate, with two stout ensiform setae on ventrolateral margin, short, slender nematoid seta subapically on medial surface; bursa copulatrix (Fig. 4) with dorsal lobe distinct, asymmetrical, ventral and ductal lobes absent; spermatheca moderate in length,



Figs. 3, 4. *B. palosverdes,* n. sp., female genitalia. 3) A, eighth tergum, dorsal aspect; B, eighth sternum, ventral aspect; C, left coxostylus, ventral aspect. 4) Bursa copulatrix and spermathecal apparatus. A, dorsal aspect; B, ventral aspect. bc = bursa copulatrix, co = common oviduct, dl = dorsal lobe, sd = spermathecal duct, sg = spermathecal gland, sp = spermatheca. Scale lines = 0.1 mm.

rounded apically, constricted subapically, broadest in basal half; spermathecal duct short, moderately thick, coiled with two reversed half-turns, inserted near midline on dorsal surface of dorsal lobe of bursa copulatrix; spermathecal gland slender, simple, inserted on spermatheca near middle through a broader tubular reservoir.

GEOGRAPHICAL DISTRIBUTION.—Known only from Point Vicente and Point Fermin on the Palos Verdes Peninsula, Los Angeles County, California (Fig. 5).

HABITAT DISTRIBUTION.—Derham Giuliani (personal communication) recalls finding all the known specimens of this species in the rocky intertidal zone, at low tide in June 1964, under rocks loosely embedded in substrate. One of us (DHK) and two assistants visited both known localities for this species on May 22 and 23, 1990. We searched in the rocky intertidal zone at both high and low (−1.4 ft) tides in all microhabitats from the surf edge to five meters above the highest high tide line, during both day and night. No

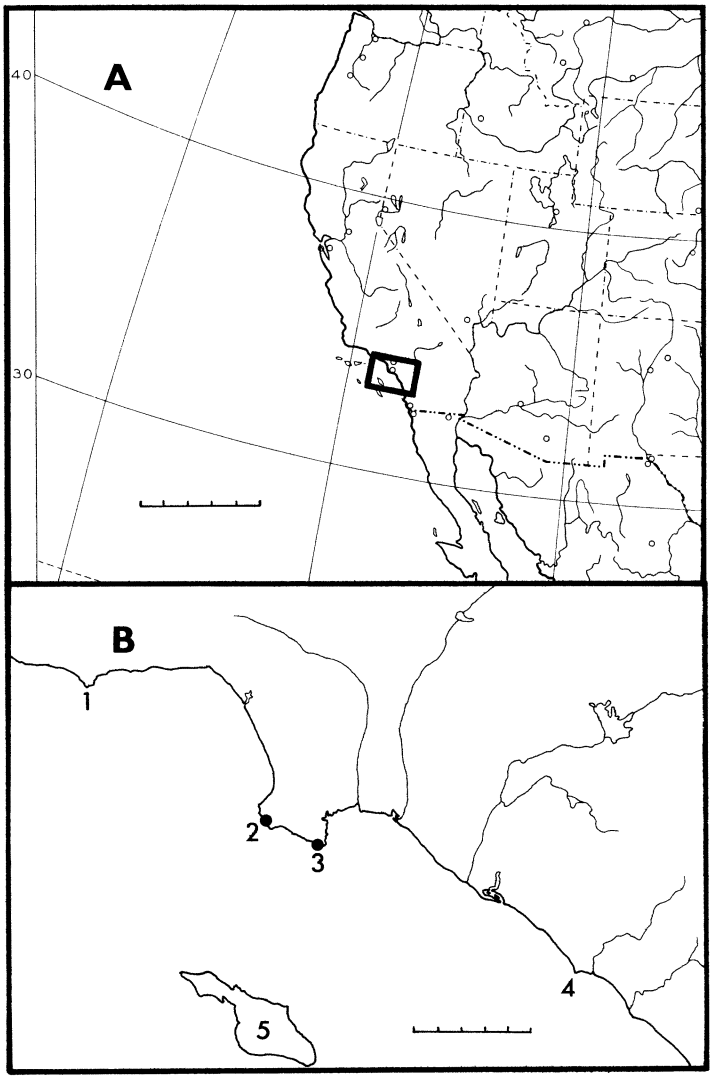


Fig. 5. Known geographical distribution of *Bembidion palosverdes,* n. sp. A, map of westcentral North America with inset, scale units = 50 km, small open circles = major cities; B, enlargement of inset, Palos Verdes Peninsula and adjacent coastline, scale units = 5 km, solid circles = known localities for this species. 1 = Point Dume, 2 = Point Vicente, 3 = Point Fermin, 4 = Dana Point, 5 = Santa Catalina Island.

members of this species were found at either locality on this occasion. Nonetheless, we suggest that, if still extant, this species is probably confined to the rocky intertidal zone on the Palos Verdes Peninsula. No other *Bembidion* species in North America is known to be restricted to or even occur in this

habitat. Members of *B. laticeps* LeConte apparently occur only in sandy beach habitats, where they are found under driftwood or beach wrack.

LIFE HISTORY.—Like most carabid beetles, both adults and larvae of this species are probably predators, most likely on other intertidal insects or other arthropods (*e.g.*, amphipods). All known specimens are adults and were collected in June. One of these is markedly teneral, indicating recent eclosion from the pupal stage at that time. Failure to find adults in late May 1990 may reflect a marked seasonality in life cycle timing; but it is more likely that the small size and intertidal habits of these beetles simply render them very difficult to find at any time. Nothing else is known at present about the life history of this species.

PLACEMENT IN LINDROTH'S KEYS TO SPECIES AND SPECIES GROUPS

The following modifications to Lindroth's (1963) key to species, at couplet 83 (page 218), are required to accommodate *B. palosverdes*:

83. Elytron with apex of interval 6 markedly costate in apical half; humerus markedly sloped; wingless (intertidal zone, Pacific Coast) ..... *B. palosverdes*, n. sp.
– Combination of characters not as above 83a
83a. Elytral interneurs markedly punctate, at least in basal half; metasternal process (between mesocoxae) entirely unmargined 84
– Elytral interneurs smooth or micropunctulate; metasternal process with raised margin, at least laterally 91

The following modifications to Lindroth's (1963) key to species groups, at couplet 2 (page 208), are required to accommodate a group not previously recorded from North America and to which we tentatively refer *B. palosverdes*.

2. Eye size small, longitudinal diameter less than or equal to length of scape 3
– Eye size moderate or large, longitudinal diameter much greater than length of scape 4
3. Elytron with discal setiferous punctures confluent with interneur 3 ..... *laticeps* group
– Elytron with discal setiferous punctures free of interneur 3 on interval 3 ..... *oblongulum* group
4. Elytron with 3 discal setiferous punctures 4a
– Elytron with 2 discal setiferous punctures 5
4a. Humerus absent, elytral margin sloped to near scutellum; wingless ..... *laterale* group
– Humerus present, prominent; winged ..... *scudderi* group

Erwin and Kavanaugh (1980) demonstrated that *Bembidion puritanum* Hayward was the European *Bembidion nigropiceum* Marsham and suggested that it was no longer extant in North America. We have therefore deleted Lindroth's *puritanum* group (= *nigropiceum* group from Europe) from the modified key.

We disagree with Lindroth's observation that *laticeps* group members lack an abbreviated scutellar interneur. In fact, all members of this group have this structure, which can be readily discerned with adequate magnification and

lighting at the proper angle. We have therefore used a more appropriate characteristic to distinguish this group in the modified key.

Lindroth (1963, page 209, couplet 22, and page 351) also erred when he stated that the dorsal setiferous punctures of the elytra in members of the *scudderi* group are free of interneur 3 on interval 3. His illustration of *Bembidion scudderi* LeConte (his Fig. 176, page 352) clearly shows their position confluent with interneur 3; and he correctly notes the true arrangement in *B. scudderi* on page 407, in his discussion of *Phrypeus rickseckeri* Hayward, members of which also have the setiferous punctures confluent with interneur 3.

Relationships with Other Bembidiines

We have aligned *B. palosverdes* with *B. laterale* of coastal Western Europe and North Africa in what Lindroth (1974, 1980) regarded as subgenus *Cillenus* Samouelle. All other intertidal *Bembidion* species (including, among others, *B. laticeps* LeConte, *B. nigropiceum* Marsham, and *B. yokohame* Bates) represent other subgenera (Lindroth, 1980). Our hypothesis of close relationship between *B. palosverdes* and *B. laterale* is based on the following shared character states: head with postocular region robust; antennae short and stout, with antennomeres submoniliform; mandibles porrect and of intermediate length; elytron with interneur 3 plurisetose (3 or 4 setiferous punctures); male aedeagus with chitin plates CH2, CH3, CH4, and CH5 styliform.

We are not yet prepared to identify which of the above character states are synapomorphic and which are symplesiomorphic. Until all or at least most groups of *Bembidion, s. lat.,* have been adequately studied and subjected to cladistic analysis, we cannot confirm the monophyly of the *laterale* group nor identify its sister taxon. We note here, however, that the only other presumed *Bembidion* lineage with plurisetose elytral interneur 3 (probably an apomorphic feature among bembidiines) is the *scudderi* group (Lindroth 1963:351). Males of both the *laterale* and the *scudderi* groups also share a common configuration of sclerites in the aedeagal internal sac. In addition, all known members of both groups are restricted to saline habitats—*laterale* group members to intertidal coastal habitats, *scudderi* group members to inland saline lake and pond shores. Previously (Kavanaugh and Erwin 1991), we have suggested vicariance relationships between sister groups in coastal and interior saline habitats, specifically for both cicindines and pogonines. This pattern is likely to occur also in the bembidiine genus *Tachys* (unpublished data, TLE). The geographical/ecological pattern seen between the *laterale* and *scudderi* groups indeed may reflect true phylogenetic relationship as well.

Present Status of the Species and Conservation Issues

Intertidal areas in southern coastal California already have been studied extensively, particularly for Carabidae (Evans 1970, 1977, 1985) and Staphylinidae (Moore and Legner 1976, and references therein). Consequently, the discovery of this new species, *B. palosverdes,* among unsorted museum specimens was unexpected. Its known geographical range is highly restricted, which may account for the fact that it escaped earlier discovery. Whether the known range represents the full range of the species at present or is simply an artifact of insufficient sampling in the rocky intertidal habitat elsewhere along the southern California coast and on the Channel Islands is uncertain. To resolve this question, additional fieldwork must be undertaken. The present occurrence of *B. palosverdes* on the Palos Verdes Peninsula, where the species is known

to have occurred in 1964, must be confirmed. Sampling over a broad seasonal range may be required to either confirm or deny its presence. Other potentially suitable localities must be sampled as well. On the mainland, the closest additional sites with potentially suitable habitat are at Point Dume and Dana Point (Fig. 5B). Various rocky shores on the Channel Islands, especially on Santa Catalina Island, must also be sampled.

Because these beetles are so small (less than 3 mm in length), they may be difficult to find, even where they occur. Nonetheless, there is reason to suggest that their occurrence at Palos Verdes, where they now may be extinct, represents the full extent of their Recent distribution. As noted and illustrated by Miller (1985), much of the present mainland coastline and extensive portions of the present Channel Islands were submerged by higher sea levels during the Middle Pleistocene, due to a combination of eustatic and tectonic changes. However, portions of the Palos Verdes Peninsula appear to have remained above sea level throughout the entire period (for the last 500,000 years), at least as an island surrounded by sea, thus potentially available as a refugium for terrestrial and/or intertidal organisms, such as *B. palosverdes.* Few if any other areas along the southern mainland coast could have provided appropriate habitat for this species throughout the Pleistocene. Late Pleistocene (*ca.* 18,000 years ago) sea level depressions exposed broad coastal areas presently below sea level and united some of the Channel Islands into larger islands (Miller 1985). Such events may have exposed suitable habitat that could serve as avenues of dispersal for some organisms out of restricted refugia. The nearest extant areas of potentially suitable habitat for *B. palosverdes* are about 50 and 65 kilometers to the northwest and southeast, respectively, from the Palos Verdes Peninsula, separated from the latter by areas of sandy beaches. Whether or not these or any other present rocky intertidal areas have been linked with the Palos Verdes Peninsula in Pleistocene or Recent times by corridors of suitable habitat is unknown.

If *B. palosverdes* no longer inhabits the Palos Verdes Peninsula, then it already may be an extinct species. If it is restricted to the peninsula and still resides there, its future must be considered threatened. Although the two known localities are relatively well protected from shore-based human activity or modification (Point Vicente is in a nature reserve controlled by Los Angeles County and Point Fermin is part of Point Fermin Park, under the supervision of the Los Angeles City Department of Recreation and Parks), they are still under the threat of potentially disastrous offshore oil spills. During the previously mentioned sampling at Point Fermin, numerous small globules of oil and/or tar were observed on the shoreline rocks. The origin and age of this material is unknown, as is the extent to which this or any other oil deposited on the shores of the peninsula in the past has affected populations of *B. palosverdes.* However, numerous specimens of *Thalassotrechus barbarae* (Horn), another carabid species inhabiting rocky intertidal areas, were seen at Point Fermin. This species is known to be highly susceptible to extermination by oil deposited on shore (Evans 1970), and its continued occurrence is viewed as an encouraging indication of the integrity of the intertidal fauna there.

In anticipation of interest from the conservation community and recognition of the fact that a common name inevitably will be attached to this species, we suggest the name "Palos Verdes intertidal minute carabid beetle" for use where the scientific name is not used. White (1983) presented "minute ground beetles" as the common name for members of the tribe Bembidiini. Because many Carabidae, especially in tropical regions, are not ground-dwelling, we substitute

the term "carabid beetle" for "ground beetle" as the family level common name but otherwise follow White's usage for the tribal level name.

Clearly, there is an urgent need for additional study of this species and its distribution. Hopefully, this preliminary report will stimulate such a study and not serve merely as a *post mortem* for the species.

Acknowledgments

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