MONTEREY ROACH
***Lavinia symmetricus subditus* (Snyder)**

Status: Moderate Concern. Although Monterey roach do not appear in danger of extinction in the near future, populations could decline rapidly and disappear in many areas as the result of alterations to streams and changes in climate.

Description: This subspecies differs from the 'type' subspecies, *L. s. symmetricus,* by having fewer dorsal (7-9, mean 8.0) and anal fins rays (6-8, mean 7.3), fewer scales in the lateral line, slightly shorter fins, a slightly more robust body and a thicker caudal peduncle (Snyder 1913, Murphy 1948c, Hopkirk 1973). Coloration is deep olive above, silvery to whitish beneath. See the Central California roach account in this report for a more complete description of general roach morphology.

Taxonomic Relationships: The Monterey roach was first described as *Hesperoleucus subditus* by Snyder (1913) from Uvas creek, tributary to the Pajaro River, Santa Clara County. While the type specimen appears to be a "pure" roach, some of Snyder's specimens later proved to be hitch/roach hybrids (Miller 1945b). Snyder had noted that a large portion of his atypical specimens (those having 8 instead of 7 anal fin rays) came from a single collection point in the mainstem Pajaro River, but it was not until 1945 that these individuals were recognized by Robert Rush Miller as hybrids with hitch (*L. exilicauda*). Miller (1945b) showed that hybrids had intermediate morphological characters to their parent species and insinuated that drought conditions may have played a role in hybridization, by bringing the two normally allopatric species together in remnant pools. Avise et al. (1975) found that, while hybridization was present between the two species in the Pajaro River, it was localized and introgression was unusual.

Recent genetic evidence suggests that Monterey roach are most closely related to roach from tributaries to south San Francisco Bay (Aguilar and Jones 2009). This relationship is supported by strong geologic evidence for past hydrologic connections between the Coyote Creek watershed (San Francisco Bay drainage) and the Pajaro River watershed (Branner 1907, Dupre 1990). Snyder (1913) proposed that colonization of the Monterey basin by freshwater fishes from the Sacramento River took place via this hydrologic connection in two distinct events. The first such event transferred roach, Sacramento sucker (*Catostomus occidentalis*) and speckled dace (*Rhinichthys osculus*). These three species then spread throughout the Monterey Bay drainage system which, because of lower sea levels, had a fluvial connection to the San Lorenzo River. Subsequent sea level rise resulting from melting continental ice sheets then cut off the San Lorenzo from the Pajaro/Salinas system before the second colonization event transferred the remainder of the fish assemblage from Coyote Creek to the Pajaro River.

Murphy (1948c) presented his own dual colonization theory to explain the depauperate San Lorenzo fish assemblage. He proposed that the first colonization came not from San Francisco Bay but from the west side of San Joaquin Valley, transferred into the headwaters of the San Benito River (tributary to the Pajaro) by stream capture. This purported connection was not supported by recent genetic analysis which, instead, showed a strong relationship between fish in the San Lorenzo and adjacent coastal creeks and roach from San Francisco Bay tributaries. Fish from Los Gatos Creek (San Joaquin tributary) and from the upper San Benito, however, were not included in the study, so their relationship to each other and to roach from other Monterey Bay sub-basins remains unclear. The genetic evidence does suggest that headwater capture in the geologically active Santa Cruz Mountains (headwaters of streams which flow both directions are bisected by the San Andreas fault) has facilitated fish transfer from San Francisco Bay drainages (Sacramento basin) to the San Lorenzo (Monterey basin) and adjacent coastal systems (Jones 2001, Aguilar and Jones 2009). Further genetic analysis is needed to clarify both the colonization history of the Monterey basin and the phylogenetic relationships of Monterey roach.

Life History: Few data specific to Monterey roach exist; however, the following generalized description of roach life history is based on data from other roach populations which are thought to be similar (Moyle 2002).

Roach are opportunistic omnivores whose diet varies greatly across watershed, habitat type and season. In small, warm, streams they primarily graze filamentous algae, which is seasonally abundant, although they also ingest crustaceans and aquatic insects (Fry 1936, Fite 1973, Greenfield and Decket 1973). Juvenile roach consume large quantities of crustaceans and small chironomid midge larvae, while adult roach are more opportunistic feeders, feeding both off the substrate and from drifting insects in the water column. As a result of their benthic feeding habits, the stomach contents of adult roach are often found to contain considerable amounts of detritus and fine debris. It is thought that roach extract some nutritional value from this material because it is retained by the gill rakers and by mucus secretions from epithelial cells (Sanderson et al. 1991).

Growth is highly seasonal, with most rapid growth typically occurring in early summer (Fry 1936, Barnes 1957). In perennial streams, roach frequently exceed 40 mm SL in their first summer, reach 50-75 mm by their second year and reach 80-95 mm SL by their third summer (Roscoe 1993, Fry 1936). Few individuals exceed 120 mm SL or live beyond 3 years.

Roach typically mature at 45-60 mm SL in their second or third year (Fry 1936). Fecundity is dependent on size and ranges from 250 – 2,000 eggs per female (Fry 1936, Roscoe 1993). Spawning activity is largely dependent on temperature and typically occurs in March through early July, when water temperatures exceed 16˚C. Spawning occurs in riffles over small rock substrates that are 3-5 cm in diameter. Roach spawn in large groups over coarse substrates. Each female repeatedly deposits eggs, a few at a time, into the interstices between rocks where the eggs are immediately fertilized by one or more males. Spawning aggregations can be quite conspicuous and spawning fish can splash so vigorously that, at times, the splashing can be heard at some distance (Moyle 2002). This activity clears silt and sand from gravel interstices and improves adhesion for sticky fertilized eggs. Eggs hatch after 2-3 days and larvae remain in the gravel until large enough to actively swim.

Habitat Requirements: California roach are generally found in small streams and are particularly well adapted to life in intermittent watercourses, where dense populations are frequently observed in isolated pools (Fry 1936, Moyle et al. 1982, Leidy 2007). Smith (1982) found that, in the Pajaro River, Monterey roach have similar requirements to California roach in other areas. They were generally associated with pools in unshaded and warm tributaries in relatively undisturbed areas. While most abundant in clear, well oxygenated streams, roach were also present in areas where dissolved oxygen levels were < 1ppt (Smith 1982).

They can tolerate a relatively wide range of temperatures and dissolved oxygen levels and are found in habitats ranging from cold, clear, well-aerated 'trout' streams to intermittent streams where they can survive extremely high temperatures (30 to 35˚ C) and low dissolved oxygen levels (1-2 ppm) (Taylor et al. 1982, Knight 1985, Cech et al. 1990). Smith (1982) found Monterey roach reached their highest densities in quiet, unshaded pools.

Although emblematic of streams that support native fishes, roach are most abundant when found by themselves or with just one or two other species (Moyle and Nichols 1973, Leidy 1984, 2007, Brown and Moyle 1993). When found alone, roach will occupy open water in large pools; when found as part of complex assemblages, roach tend to congregate in low velocity (<40 cm/sec), shallow (<50cm) habitats (Moyle and Baltz 1985). Smith (1982) noted that, in the presence of hitch, Monterey roach tended to favor shallower, faster water. In the presence of native predators, roach are also restricted to the edges of pools, riffles and other shallow water habitat or to dense cover, such as that provided by fallen trees.

Distribution: Monterey roach are confined to the Pajaro, Salinas and San Lorenzo river systems, all tributary to Monterey Bay. Within the Pajaro watershed, Monterey roach do not occur in the mainstem Pajaro River but are present in Uvas Creek, Llagas Creek upstream of Chesbro Reservoir, North Fork of Pacheco Creek upstream of Pacheco Reservoir, Arroyo Dos Picachos and in the San Benito River and it tributaries, including Tres Pinos, Laguna, and Clear creeks, among others (Smith 2007). In the Salinas River system, roach have been extirpated from the mainstem habitats they historically occupied and now occur primarily in tributaries such as Arroyo Seco (J.J. Smith, pers. comm. 2009) and Gabilan Creek (Hager 2001). Roach are native to and numerous in the San Lorenzo River and Pescadero Creek and are present in smaller numbers in Soquel Creek, to which they may have been introduced. Snyder (1913) did not collect roach in Soquel Creek; however, he sampled only one site and their presence may not have been detected.

Trends in Abundance: Monterey roach are numerous but have been extirpated from reaches of the Pajaro and Salinas river systems due to habitat alteration and degraded water quality and quantity (Smith 1982, 2007). Long-term trends are not known but populations are likely fewer and more fragmented than they were historically.

Nature and Degree of Threats: Monterey roach are an exceptionally hardy fish that can tolerate high temperatures and low dissolved oxygen levels lethal to most other California native fishes. Nevertheless, they exist in a rapidly changing environment which is threatened by climate change and increasing human demand for water (Table 1). This is compounded by the fact that the vast majority of Monterey roach habitat occurs on private lands, where there is little formal protection for aquatic organisms.

Major dams. As part of the Habitat Conservation Plan for Santa Clara County (2007), Jerry Smith of San Jose State University wrote:

"Monterey roach have been lost from some habitats in the Pajaro River system due to construction of reservoirs. Attenuated winter flows from the reservoirs have apparently allowed hitch (*L. exilicauda*), a native minnow of downstream habitats, to expand upstream into Pacheco, Uvas and Llagas creeks below the reservoirs. Abundant hitch can reduce the closely related roach by competition and hybridization (Smith 1982). Uvas Reservoir frequently spills during large floods, so hitch abundance fluctuates from scarce to common in Uvas Creek, but they are always less abundant than roach. Roach are now absent from Llagas Creek and Pacheco Creek downstream of the reservoirs. The loss of roach in Llagas Creek occurred in 1977 when drought dried the streambed downstream of the reservoir and eliminated roach; although present upstream of the reservoir, roach have not been able to recolonize through the reservoir in the almost 30 years since the drought (Smith 1982, 2006). Transplanting roach from above to below the reservoir would reestablish the species in lower Llagas Creek."

Agriculture. The Salinas Valley is one of the most intensively farmed areas in California. Consequently, hydrodynamics and stream morphology in the valley have been severely altered, creating inhospitable lowland habitats and leading to isolation of roach populations in headwater tributaries.

Grazing. Grazing takes place mainly in the lower elevation hills along streams which are the main habitat of Monterey roach; grazing contributes to streams incision and to intermittent streams drying more quickly and completely.

Rural residential. Increasing rural population density, particularly in Santa Cruz County, has dramatically increased human impacts on small streams through increased water withdrawal, especially in summer months when flows are reduced, and through pollution from faulty septic systems and surface runoff from roads and other hardscapes, as well as habitat simplification and fragmentation from road crossings, development adjacent to streams and other factors.

Urbanization. As the human population in the Monterey basin has grown, water demand has exceeded supply. Groundwater is the primary source to meet agricultural and urban needs and salt water intrusion due to over-pumping from groundwater aquifers currently threatens all coastal water supplies for both municipal and agricultural uses. Urbanization also leads to stream channelization, habitat simplification, pollution input and other impacts that degrade roach habitats.

Logging. Historically, logging in the Monterey Basin was primarily limited to the San Lorenzo River watershed. However, logging is currently of little consequence due to its diminished scope as the watershed is increasingly converted to urban and rural-residential uses.

Fire. While fire is a natural part of the California landscape, catastrophic wildfires are becoming more frequent and severe as a consequence of fire suppression, human land use and increasing temperatures and aridity (Thompson et al. 2012). Because roach populations are increasingly isolated from one another due to human alterations of stream systems (e.g., agriculture, dams, reservoirs, introduced fishes), populations affected by fires are more likely to be extirpated without the possibility of natural recolonization.

Alien fishes. Alien fishes, especially centrarchids, are widespread in the watersheds containing Monterey roach, especially in ponds and reservoirs. They represent a threat through predation and competition, especially during periods of drought when roach may be confined with alien fishes in small pools.

	Rating	Explanation
Major dams	Medium	Unfavorable stream flow alterations from multiple dams
Agriculture	Medium	Monterey basin streams have been diverted, channelized, polluted and otherwise altered by intensive agriculture
Grazing	Medium	Grazing is a major use of private lands and is often concentrated along streams
Rural residential	Medium	Residential water withdrawal may be a principal cause of decreased summer flows in small, high gradient streams, especially within the San Lorenzo watershed
Urbanization	Medium	Urbanized areas reduce habitat quantity and quality through stream alteration, fragmentation, channelization, water removal and pollution
Instream mining	Low	Gravel mining alters habitats; greater historic impacts
Mining	Low	Of little direct effect, although residue from mercury mines may have localized effects
Transportation	Low	Many streams have been altered by roads and culverts, possibly fragmenting habitats
Logging	Low	Little contemporary logging in the Monterey basin
Fire	Medium	Isolated populations may be extirpated by fire without opportunity for natural recolonization
Estuary Alteration	Low	Intolerant of salinity levels in some estuaries
Recreation	n/a	
Harvest	n/a	
Hatcheries	n/a	
Alien species	High	Intolerant of introduced predatory fish, especially centrarchids

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Monterey roach. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is low, due to lack of available data. See methods section for descriptions of the factors and explanation of the rating protocol.

Effects of Climate Change: Although Monterey roach are well adapted to the warm, arid conditions of the basin's Mediterranean summers, their dependence on pools in intermittent streams suggests that they are also particularly susceptible to increasing aridity associated with climate change, despite their tolerant physiology. Roach can be extirpated from streams which currently maintain isolated, disconnected, pools in summer if the streams dry completely under the dual strains of reduced rainfall and increased human water use, including groundwater withdrawal. Thompson et al. (2012) indicated that, under moderate climate change scenarios, streams in the Salinas River watershed could become less suitable for fish through increased temperatures, decreased flows and loss of woody debris, important as cover for roach and other species. Loss of woody debris recruitment into streams may potentially occur because of the likely increase in wildfires, which could also change the dominant vegetation from forest to grasslands. Riparian trees and other vegetation will be maintained only if diversions and other factors affecting instream flow do not contribute to further drying of streams. Because Monterey roach live mainly in small streams in watersheds that are especially prone to desiccation due to drought, Moyle et al. (2013) rated them as "highly susceptible" to the predicted impacts from climate change.

Status Determination Score = 3.4 - Moderate Concern (see Methods section Table 2). Monterey roach are still common throughout much of their native range, although populations are fragmented and subject to localized extinctions. The Monterey roach is listed by NatureServe as "G5T2T3, Imperiled".

Metric	Score	Justification
Area occupied	3	Confined to streams tributary to Monterey Bay, plus Pescadero Creek to the north
Estimated adult abundance	5	Numerous large populations
Intervention dependence	4	Little management of primary habitats occurs, yet populations persist
Tolerance	4	High environmental tolerances
Genetic risk	3	Human alteration to river courses has facilitated an increase in roach/hitch hybridization
Climate change	3	Decreased flows, along with increased water demand, is likely to reduce available habitat
Anthropogenic threats	2	See Table 1
Average	3.4	24/7
Certainty (1-4)	2	Very little published information available

Table 2. Metrics for determining the status of Monterey roach, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

Management Recommendations: Genetic research is needed in order to elucidate the phylogenetics of Monterey roach. Of particular interest are the relationships between fish in the upper San Benito River and those in Los Gatos Creek on the west side of the San Joaquin Valley. Findings may shed light on the radiation of California's native fish fauna and provide insights into the geologic formation of the central Coast Ranges.

Although Monterey roach populations remain geographically widespread, their status should be monitored at least once every five years to determine if there is attrition in their increasingly isolated populations. Particular attention should be paid to areas that have suffered from wildfires. If local extirpations occur, a management plan should be developed to maintain flows in key streams and restore extirpated populations, potentially through reintroduction, where necessary. Consideration should also be given to the reintroduction of roach into watersheds with suitable habitats in which they were historically present but have since been extirpated. Priority should be given to the reestablishment of roach in lower Llagas Creek via transplantation from above Chesbro Reservoir. Likewise, the opportunity exists to reestablish roach in Pacheco Creek via transplants from above Pacheco Reservoir.

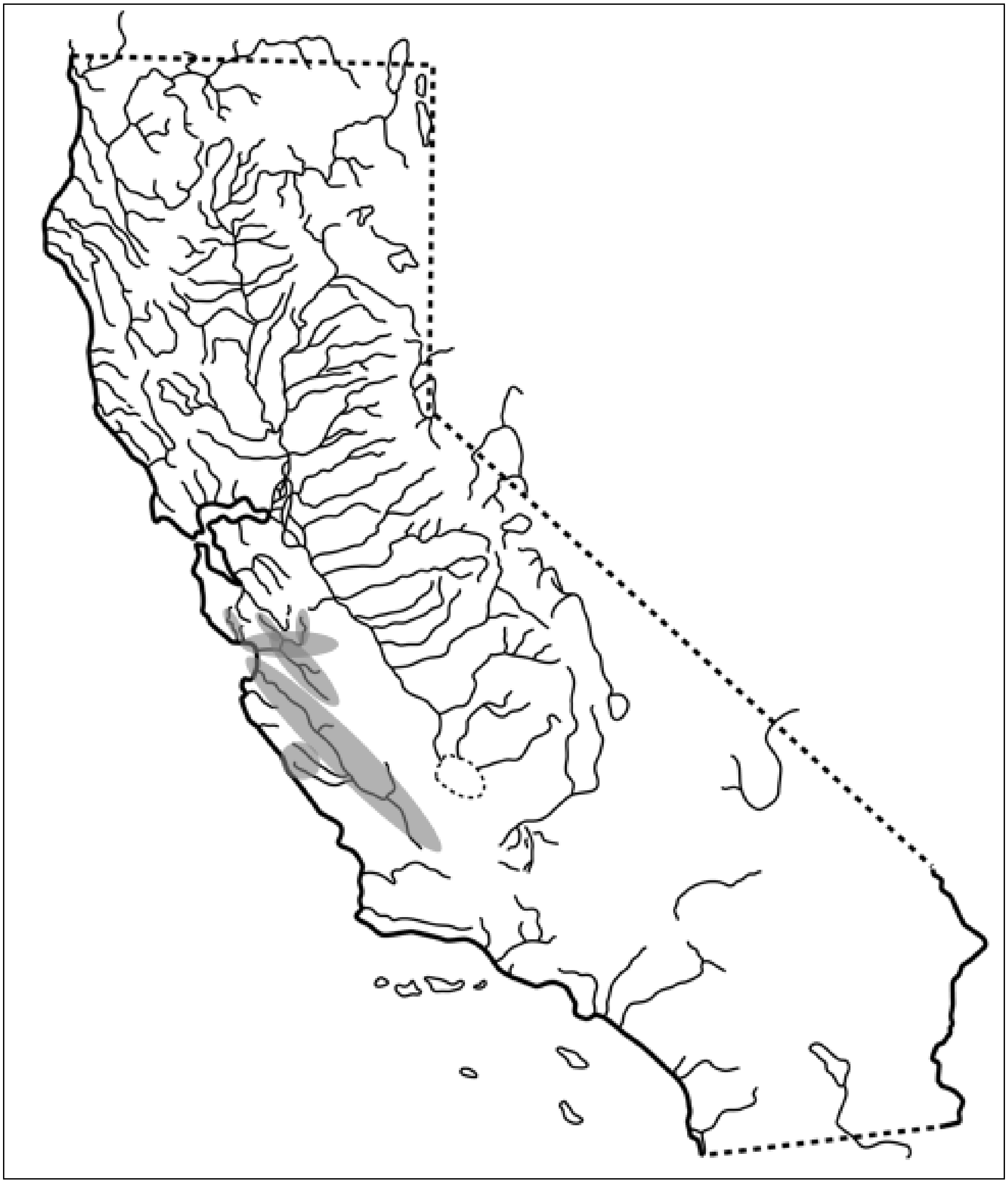

Figure 1. Generalized distribution of Monterey roach, *Lavinia symmetricus subditus* (Snyder), in California. Actual distribution is likely fragmented.