Accurate Identification of *Zootermopsis* Species (Isoptera: Termopsidae) Based on a Mandibular Character of Nonsoldier Castes

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ABSTRACT A mandibular character, shape and position of the subsidiary tooth of all nonsoldier castes, enables precise identification of the three currently recognized species of the North American termite genus *Zootermopsis* Emerson. Use of this character resolves the problems of discriminating Z. *angusticollis* (Hagen) and Z. *nevadensis* (Hagen) based on previously described, often ambiguous, characters of soldier or imago morphology. Species may now be identified using immatures and pseudergates, which are abundant in colonies throughout the year.

KEY WORDS Insecta, *Zootermopsis angusticollis*, *Zootermopsis nevadensis*, dampwood termites

THREE SPECIES in the genus *Zootermopsis* Emerson are currently recognized; all are restricted to western North America (Weesner 1970). Z. *laticeps* (Banks) is found in moist, rotting wood in living willow, cottonwood, and sycamore trees along water courses in central and southeastern Arizona, southwestern New Mexico, and northern Mexico (Banks & Snyder 1920, Castle 1934, Nutting 1965, Weesner 1970). Z. *angusticollis* (Hagen) and Z. *nevadensis* (Hagen) are reported to range throughout the Pacific coastal United States north to British Columbia and into parts of Idaho, Montana, and western Nevada (Banks & Snyder 1920, Castle 1934, Weesner 1970). Z. *angusticollis* is commonly found in dead trees, logs, and stumps of numerous coniferous and hardwood species and in structural wood in moist climates along the Pacific Coast. Z. *nevadensis* (or the Z. *nevadensis* complex [see Discussion]) lives in a similar habitat and occurs sympatrically with Z. *angusticollis* throughout most of its range, but it also extends to the cold, dry, high elevations of the Sierra Nevada, Coast Range, and Cascade and Rocky Mountains.

Z. *laticeps* is easy to distinguish from either Z. *angusticollis* or Z. *nevadensis* based on external morphology and geographical distribution. The anterior lateral corners of the pronotum are distinctly angulate on all castes of Z. *laticeps*, but they are rounded on all castes of Z. *angusticollis* and Z. *nevadensis* (Sumner 1933, Snyder 1954). Z. *laticeps* soldiers are large (16–22 mm long) (Nutting 1965) with a broad head and mandibles about as long as the head (Weesner 1965). Z. *laticeps* alates are much larger than either of the coastal species (alates 25–30 mm, including wings) (Nutting 1965), with long, broad wings which are a light amber-brown color (Weesner 1965).

Taxonomic discrimination of Z. *angusticollis* and Z. *nevadensis*, however, has long been recognized as a challenging task with an admitted risk of error. Previous species descriptions and dichotomous keys for soldiers and alates are often ambiguous, presenting size, shape, or color diagnostics which are "usually" representative (Sumner 1933, Weesner 1965). Winged imagoes are considered to have the best characters for discriminating the two species. Body and wing colors of Z. *angusticollis* are generally lighter than those of Z. *nevadensis*, and wings of Z. *angusticollis* are "typically" longer and broader (Banks & Snyder 1920, Sumner 1933, Snyder 1954, Weesner 1965).

Unfortunately, alates are not always available, and their diagnostic characters are not completely reliable. Cleveland (1924) wrote that he could not distinguish between Z. *angusticollis* and Z. *nevadensis* because there were no winged adults. Sumner (1933, 212) writes of the two species that "all castes, except the alates, have in the past been generally considered indistinguishable, and even occasional specimens of the winged reproductives have been problematical." Heath (1927, 410) comments, "The winged adults of *Termopsis* (now *Zootermopsis*) *nevadensis* may be readily distinguished from *T. angusticollis* not only by their smaller size but also by a much darker coloration. There are, however, rare colonies of the first-named species in which the color almost exactly duplicated that of its near relative."

Banks & Snyder (1920) and Snyder (1954) found no consistent characters to distinguish soldiers of Z. *angusticollis* from Z. *nevadensis*, and in their keys they placed both species in the same couplet choice. Sumner (1933) and Weesner (1965) discriminate soldiers of Z. *angusticollis* from Z. *nevadensis* based on the shape of the head. Both

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authors noted that in typical Z. *nevadensis* soldiers, the sides of the head are almost parallel, whereas the head capsules of Z. *angusticollis* soldiers are broader at the posterior than at the anterior end. Also, in Z. *nevadensis* soldiers, the ratio of mandible length to head width is "almost always" higher than in Z. *angusticollis* soldiers.

These characters often are useful in mature colonies with large soldiers, but small soldiers (from juvenile, young, or small colonies) often remain difficult to distinguish and yield equivocal determinations. Termite taxonomists often must spend much time measuring and comparing specimens to identify Z. *angusticollis* or Z. *nevadensis*, and scientists are not always in agreement when asked to identify the same specimens (see Haverty et al. 1988). We describe here a mandibular character, the shape and position of the subsidiary tooth, that enables accurate diagnosis of Z. *angusticollis*, Z. *nevadensis*, and Z. *laticeps*.

Shape and Position of the Subsidiary Tooth

A small subsidiary tooth is present at the base of the anterior edge of the first marginal tooth on the right mandible of nonsoldiers of all genera within the Termopsidae (Ahmad 1950). The subsidiary tooth of a dissected mandible is readily visible with a dissecting microscope and is most easily seen when viewing the dorsal side of the mandible with the plane of the apical tooth and first marginal tooth parallel to the microscope stage (Fig. 1a).

Shape and position of the subsidiary tooth can be consistently and accurately used to diagnose both sexes of all nonsoldier morphs of Z. *angusticollis* and Z. *nevadensis*. In Z. *angusticollis*, the tooth is broadly fused to the base of the first marginal tooth; the subsidiary tooth apex is obscured by the fusion (Fig. 1b). The subsidiary tooth is more detached in Z. *nevadensis*, with a distinct, pointed tip clearly visible (Fig. 1c). In Z. *angusticollis*, the angle formed by the junction of the subsidiary tooth and the first marginal tooth equals or exceeds 90°; in Z. *nevadensis* the angle is much less than 90°. The shape and position of the subsidiary tooth is intermediate in Z. *laticeps*, appearing partly fused, but the subsidiary tooth apex remains separate from the side of the first marginal tooth (Fig. 1d).

Mandibles from any individual with sclerotized mandibles may be examined: large "larvae," pseudergates, nymphs, neotenic reproductives, alates, or primary reproductives. The subsidiary tooth character is most clearly defined, however, on alates or recently molted individuals because they have unworn mandibular surfaces. Wear on the mandible may obscure the structure of the apical and marginal teeth and of the subsidiary tooth.

The geographic origins of specimens examined are listed in Table 1. Type specimens for Z. *angusticollis* and Z. *nevadensis* are pinned imagoes in the Museum of Comparative Zoology, Harvard University, Cambridge, Mass. The specimens are already damaged, so we did not wish to cause further harm by dissecting the right mandibles. Individuals collected close to the type localities were examined.

Discussion

Because the subsidiary tooth character does not rely on a series of soldiers (relatively rare in colonies and collections) or alates (only present seasonally and absent from most samples), it can be used to determine virtually any collection of *Zootermopsis*. Large larvae or nymphs are almost always abundant, and dissection of several individuals will not reduce the value of the collection. The character also may be used to separate Z. *laticeps*, although pronotum shape and geography make distinguishing this species quite obvious.

The validity and utility of this mandible character was found during a morphological analysis of *Zootermopsis*. This study was initiated after the discovery by Haverty et al. (1988) of four qualitatively and quantitatively distinct hydrocarbon patterns among specimens of *Zootermopsis* collected throughout the western United States. They found a totally consistent correlation between hydrocarbon phenotype and the relatively reliable alate wing characters (evaluated for all samples containing alates). Haverty and his collaborators concluded that Z. *angusticollis* and Z. *laticeps* each have unique and identifiable hydrocarbon phenotypes (called phenotypes II and IV, respectively), and that hydrocarbon phenotypes I and III correspond to specimens that fit the current morphological descriptions of Z. *nevadensis*. Using the hydrocarbon phenotypes as a sorting character, Thorne examined the mandibles and found an exact correspondence between shape and position of the subsidiary tooth of the right mandible and the hydrocarbon pattern groupings of II, IV, and I + III. Subsidiary tooth morphology also sorts exactly with determinations based on alates in a large number of collections. The mandible structure does not, however, enable morphological discrimination of specimens with the two Z. *nevadensis* hydrocarbon phenotypes (for further discussion of the Z. *nevadensis* complex, see Haverty & Thorne [1989]).

Zootermopsis angusticollis and Z. *nevadensis* are common termites throughout the Pacific Coast states, are pests in structures, and play a major role in recycling dead wood in forests of the Sierra Nevada and Coastal Ranges. They are commonly used in studies of social behavior of lower termites and have been used in numerous experiments on trophallaxis, trail following, and caste differentiation. Precise, consistent taxonomic identifications are critical to evaluating the relative impact of these species and in understanding the social behavior of each species. Discovery of the mandible character described here will enable more accurate

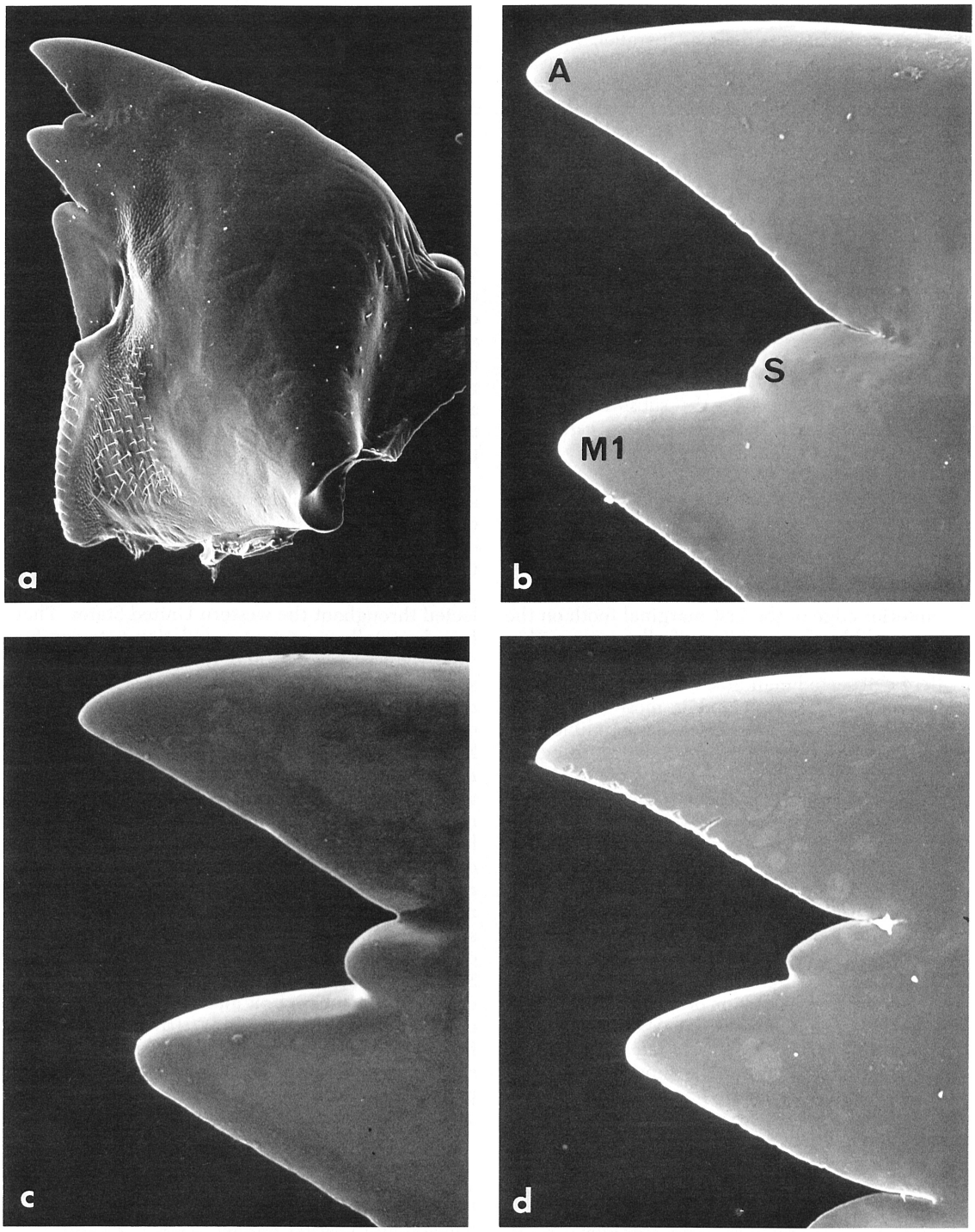

Fig. 1. Scanning electron micrographs. (a) Dorsal view of right mandible of Z. *angusticollis* (100×, male alate). (b–d) Magnified views of right mandible apical (A), subsidiary (S), and first marginal (M1) teeth of (b) Z. *angusticollis* (520×, nymph); (c) Z. *nevadensis* subsp. *nuttingi* (500×, female alate); (d) Z. *laticeps* (300×, male alate). Photo a by E. Seling and B. Thorne; photos b–d by B. Thorne.

identification of present and future collections of *Zootermopsis*. Re-examination of museum material will probably result in revised distribution maps of the *Zootermopsis* complex.

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Table 1. Specimens of *Zootermopsis* examined for subsidiary tooth character

Species	State–province	County	Site	No. colonies examined
Z. *angusticollis*	California	Humbolt	Orleans	1
			Willow Creek	1
		Mendocino	Navarro	1
		Monterey	Pacific Grove	4
		San Bernardino	Forest Falls	1
			Waterman Canyon	1
		Sonoma	Cloverdale	1
	Oregon	Benton	Corvallis	1
		Dechutes	Sisters	2
		Douglas	Camas Valley	2
			Idleyld Park	1
		Lincoln	Tidewater	1
		Linn	Foster	2
		Multnomah	Portland	1
		Washington	Forest Grove	1
	Washington	Clallam	Tatoosh Island	1
	British Columbia	—	Quesnal Lake	1
Z. *nevadensis* hydrocarbon phenotype I[a]	California	Butte	Forest Ranch	1
			Forbestown	2
		Eldorado	Grizzly Flat	13
			Omo Ranch	1
			Placerville	2
		Los Angeles	Wrightwood	2
		Riverside	Idyllwild	1
		San Bernardino	Onyx Summit	1
		Shasta	Burney	5
Z. *nevadensis* hydrocarbon phenotype III[a]	California	Humbolt	Orleans	2
		Mendocino	Navarro	1
		Monterey	Pacific Grove	5
		Shasta	Redding	2
		Siskiyou	McCloud	3
			Weed	2
		Sonoma	Cloverdale	1
		Trinity	Weaverville	2
	Oregon	Coos	Myrtlepoint	1
		Douglas	Idleyld Park	1
			Steamboat Creek	1
		Lincoln	Tidewater	2
		Linn	Cascadia	1
Z. *nevadensis* complex[b]	California	Modoc	unknown	1
	Nevada	Washoe	Reno	1
	Oregon	Tillamook	Tillamook	1
Z. *laticeps*	Arizona	Cochise	Benson	1
			Fairbank	1
			Hereford	1
			Palmerlee	1
			St. David	1
		Graham	Pima	1
		Santa Cruz	Nogales	1
			Rio Rico	1

[a] Hydrocarbon phenotype determinations were made as described in Haverty et al. (1988).
[b] These specimens were pinned alates from museum collections. It is not possible to distinguish the two hydrocarbon phenotypes of Z. *nevadensis* morphologically, hence they are grouped here as Z. *nevadensis* "complex."

Zootermopsis. We thank Bill Fowle for proficient technical training on the scanning electron microscope, and the Northeastern University Electron Microscope Center for use of the SEM. We sincerely appreciate constructive comments by Margaret S. Collins, Lynn S. Kimsey, Timothy G. Myles, David A. Nickle, and William L. Nutting on earlier versions of this manuscript. B.L.T. was supported by National Service Foundation Grant BSR-8607407 during the course of this work. Collection of specimens was supported by an Internal Competitive Grant to M.I.H., B. L. T., M. Page, and G. J. Bloomquist from the Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

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