

yet been chemically identified. Cavill & Ford (28) noted that workers of *Iridomyrmex detectus* (Fr. Smith) follow trails of 2-methylhept-2-en-6-one extracted from other *detectus* workers, but no conclusion can be drawn from this result in the absence of a quantitative bioassay. In a like manner, Blum and Wilson [in (9)] found that *I. pruinosus* (Roger) workers weakly follow trails of 2-heptanone, the natural alarm substance produced by the anal glands; but the response to the contents of individual anal glands is far less than that to the contents of a single Pavan's gland, which must be regarded as the source of the true odor trail. The notion, occasionally encountered in the literature [e.g. (85)] that workers of the *Formica rufa* group lay trails of formic acid, is without foundation. Stumper (158) has recorded a new unidentified odorant in the poison gland secretion which he suggests may be the trail substance, but no behavioral tests have been made, and the new chemical may equally well be a defensive agent working with formic acid. In *Acanthomyops* we may note that citronellal functions as a spreading agent for formic acid (57), while in *Tapinoma nigerrimum* (Nylander) iridodial traps and slows the evaporation of methylheptenone and propyl isobutyl ketone (124).

*Alarm substances.*—This category covers a variety of substances, apparently mostly terpenoids, with various behavioral effects. The expression "alarm" is only loosely appropriate. In *Pogonomyrmex badius* (Latreille), the pheromone is an attractant at low concentrations. At high concentrations it acts as an excitant, releasing the typical aggressive posture and circular running of alarm behavior, and when exposed to workers for long periods of time it causes directional digging behavior (11, 196). In *Atta rubropilosa* Forel, the alarm substance citral causes attack on the source of emission (26); a similar response is caused by the alarm substances of the New World army ants (25) and the Australian legionary ponerine *Onychomyrmex hedleyi* Emery (203). In dolichoderines the response (in some species) consists of attraction at low concentrations and attack and milling at higher concentrations. In *Tapinoma sessile* (Say), colonies exposed to prolonged dosages emigrate (208). Unlike trail substances, the alarm substances are not usually species-specific.

A few of the alarm substances have been chemically identified, as indicated in Table II. Many of the other ant secretions identified by Pavan, Cavill, and their associates [see (29, 122, 124) with contained references] will undoubtedly prove to have the same function when behaviorally tested. For instance, methylheptenone and propyl isobutyl ketone, identified in *Tapinoma nigerrimum*, are fully effective as alarm releasers in *T. sessile* (208). On the other hand, the more complex ant secretion iridomyrmecin (from *Iridomyrmex humilis*) has thus far proven behaviorally inert (203) and probably functions primarily as a biocide, as Pavan suggested originally. At least two substances, citral and citronellal in *Acanthomyops claviger* (Roger), serve both functions (30, 57). Finally, pure alarm substances applied in laboratory tests elicit the full