971) suggested that this represented a "deceptive use of song selected to acquire male nest defense." In this case, as in the Black-headed Grosbeak, such "deceptive" behavior would be adaptive since both parties would ultimately benefit by the female's singing and the male's reaction to it, i.e., the bluebird nest is defended against a possible predator and the eggs or young of the grosbeak are not left unprotected when the female leaves the nest.

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Department of Biology, UMC 53, Utah State University, Logan, Utah 84322. Present address: Department of Biological Sciences, Eastern Kentucky University, Richmond, Kentucky 40475. Received 20 November 1981. Final acceptance 10 January 1983.

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HUMMINGBIRDS FEEDING FROM EXUDATES ON DISEASED SCRUB OAK

PETER G. KEVAN

SHERRENE D. ST. HELENS

AND

IRENE BAKER

Hummingbirds are often thought to feed almost exclusively on floral nectars and occasionally hawk insects. Nevertheless, they are known to feed on fruits, from which they may remove exuded juices (Lack 1976) and sap. For example, Ruby-throated Hummingbirds (*Archilochus colubris*) may feed from holes made by Yellow-bellied Sapsuckers (*Sphyrapicus varius*) in the trunks of paper birch trees (*Betula papyrifera*; Southwick and Southwick 1980). Edwards (1982) has pointed out that various hummingbirds use secretions of insects (coccids) living beneath the bark of trees in Mexico, Colombia, and Brazil.

In this note, we describe a previously unknown food of hummingbirds: the exudate of pathogen-induced lesions on plants. We discovered this on 16 August 1981 (about 08:00) as we watched at least six Broad-tailed Hummingbirds (*Selasphorus platycercus*) and a male and a female Rufous Hummingbird (*S. rufus*) feeding extensively on exudate dripping from swollen red lesions on the undersides of twigs of Gambel oak (*Quercus gambelii*).

STUDY AREA AND METHODS

The area where we made our observations has been used previously for studies of breeding birds (St. Helens 1981, 1982). It is an 18.4-ha quadrat in the Bear Creek Nature Center, El Paso County, Colorado Springs, Colorado. The vegetation is dominated by Gambel oak and mountain mahogany (*Cercocarpus montanus*) and is typical of the dry foothills of the Front Range of the Rocky Mountains in Colorado. Affected oaks were common throughout the study area in 1981 and 1982. This area also supported small resident populations of the above species of hummingbirds.

Both liquid and crystallized samples of exudate were collected for chemical analysis. Quantitative determinations were made on crystallized material, dissolved in distilled water, by paper or acrylamide thin layer chromatography as appropriate. Sugars were identified using the methods of Baker and Baker (1979). Free amino acids were measured by staining with ninhydrin (Yemm and Cocking 1955). The dansylation technique, described by Baker and Baker (1976) and Baker et al. (1978), was used to detect amino acids. Proteins were measured using bovine serum albumin as the standard and staining with bromphenol blue (Flores 1978). We also tested for the presence of ascorbic acid with a technique that involves the rapid bleaching of 2, 6-dichlorophenolindophenol (Nordmann and Nordmann 1969), for phenols by using p-nitraniline and Folin reagent (Baker 1977), for alkaloids and other compounds containing heterocyclic N_2 with the Dragendorff test (Harborne 1973, Baker 1977), and for lipids by staining with osmic acid and Sudan IV (Jensen 1962).

We also determined the pathogen responsible for the lesions by having a specialist examine thin sections of the diseased tissue.

RESULTS AND DISCUSSION

The lesions on the oaks were apparently produced by bacteria. They contained no arthropods or fungi. Their exudate had a high ratio (1.117) of sucrose (to glucose and fructose), which is also characteristic of nectars in flowers that are pollinated by hummingbirds (Baker and Baker, in press; Table 1). However, the level of amino acids in the exudate was higher than that of most nectars taken by hummingbirds (Baker and Baker 1975). Many such nectars contain phenols, as did the exudate (Table 1).

Having seen many honeybees (*Apis mellifera*) feeding at the lesions on other days (Kevan et al., in press), we watched closely to see whether the hummingbirds were hawking insects rather than feeding on the exudate. They were not; rather, they hovered beneath the terminal twigs of the oaks and fed directly at the fluid. The male Rufous Hummingbird drove other hummingbirds off and, although they remained in the area, their feeding bouts were

TABLE 1. Chemical composition of exudate from bacterially-induced lesions on *Quercus gambelii*.

Ingredient	Concentration/presence in exudate
Sugar	872.6 μg/mg
Ratio of individual sugars	
Sucrose	0.528
Glucose	0.220
Fructose	0.252
Free amino acids[a]	0.956 μg/mg
Protein	0.932 μg/mg
Ascorbic acid	Present
Phenols	Present
Alkaloids and other compounds containing heterocyclic N_2	Not detected
Lipid	Not detected

[a] All 20 amino acids were present, including α-aminobutyric acid; glutamine, asparagine, and proline were most abundant.

consequently brief. Curiously, the birds were concentrated in a small area of about 50 × 50 m, despite the much wider availability of dripping infected trees. Because the exudate was exposed to the morning sun, it usually evaporated rapidly and crystallized (Kevan et al., in press): this would prevent hummingbirds from using it as a regular food source (see Baker 1975, Pyke and Waser 1981). However, rain the night before our observations in 1981 and the cool, damp, and cloudy morning kept the exudate watery and available to the birds. No similar observations were made in 1982, when the lesions were brown and hard and no exudate was produced.

This exudate is a novel source of food for hummingbirds but it is probably only a minor item in their diet. Throughout most of the study period it was either very viscous or had crystallized, and was thus in an inappropriate state to be used as food. The exudate is generally nectar-like in chemical composition, rather than like the honeydew secreted by insects (see Maurizio 1975) or fungal secretions (see Mower and Hancock 1975). It is not regularly available from year to year, but given the opportunistic feeding habits of hummingbirds, it may be an important item when customary foods are scarce.

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Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1, Canada. Address of second author: P. O. Box 6053, Colorado Springs, Colorado 80934. Address of third author: Department of Botany, University of California, Berkeley, California 94720.
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