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ARIZONA DISTRIBUTION OF THREE SONORAN DESERT ANURANS: *BUFO RETIFORMIS*, *GASTROPHRYNE OLIVACEA*, AND *PTERNOHYLA FODIENS*

Brian K. Sullivan¹, Robert W. Bowker², Keith B. Malmos³, and Erik W. A. Gergus³

ABSTRACT.—We surveyed historic collecting localities in south central Arizona during July, August, and September 1993–94 to determine the presence of 3 little-known Sonoran Desert anurans, *Bufo retiformis*, *Gastrophryne olivacea*, and *Pternohyla fodiens*. All 3 species were present at most historic localities visited under appropriate conditions (following rainfall in July and August). *Pternohyla fodiens* was restricted to San Simon Wash and associated tributaries in south central Pima County. *Gastrophryne olivacea* ranged from Vekol Valley in extreme southern Maricopa County south to the Mexican border, and southeast near Tucson and Nogales in Pima and Santa Cruz counties. *Bufo retiformis* occurred over the widest area, from southern Rainbow Valley in Maricopa County southwest to the vicinity of Organ Pipe Cactus National Monument, and southeast to the vicinity of Tucson and Sasabe in Pima County.

Key words: *Bufo retiformis*, *Gastrophryne olivacea*, *Pternohyla fodiens*, *historic distribution*, *present distribution*, *amphibian decline*, *Arizona*, *Sonoran Desert*.

Three relatively little-known anurans, *Bufo retiformis*, *Gastrophryne olivacea*, and *Pternohyla fodiens*, occur in the Sonoran Desert in south central Arizona. Although placed in separate families (Bufonidae, Microhylidae, and Hylidae, respectively), they are superficially similar in behavioral ecology. Each is inactive for more than 10 mon each year, emerging only to reproduce and forage following intense rainfall during the summer “monsoon” season. All exhibit “explosive” breeding behavior (Wells 1977) in which males form high-density aggregations for a few nights (sometimes only one) following a major rainstorm and call to attract females. Within Arizona all 3 species are largely restricted to a small portion of the Sonoran Desert in the extreme south central part of the state, so it is perhaps not surprising that they are relatively unknown. Indeed, *Bufo retiformis* was described in 1951 based on specimens collected southeast of Ajo in 1948 (Sanders and Smith 1951), and *Pternohyla fodiens* was first documented in Arizona in 1957 (Chrapliwy and Williams 1957, Williams and Chrapliwy 1958).

Given limited information on these Arizona anurans, this investigation was undertaken in 1993 and 1994 to ascertain their present distribution in Maricopa, Pima, Pinal, and Santa

Cruz counties, Arizona. First, we describe methods used in conducting the survey. Then, for each target species surveyed, we describe distinguishing acoustic characteristics and outline historic and present distributions. Last, we present observations on breeding behavior.

MATERIALS AND METHODS

Survey Methods

All surveys were conducted along paved roads throughout the known ranges of the 3 target species following rainstorms during July, August, and September 1993–94. Given the highly unpredictable and variable nature of summer rainfall and the need for monitoring the entire south central portion of Arizona, we could only crudely estimate (e.g., weather reports) the appropriateness of field conditions (i.e., level of rainfall) for anuran activity prior to each field excursion. Whenever sufficient rainfall appeared to have fallen in the study area, we traveled to that particular area on the night of the rainfall event, or the following night, to survey for amphibians along roadways. Frequently, 2–3 nights of surveying occurred for each rainfall event. Occasionally, survey plans were adjusted to take advantage of local conditions (e.g., localized flooding).

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To conduct surveys we drove slowly (40–65 kmph) along paved roadways scanning for anurans on the road surface and listening for chorus activity adjacent to the roadway. Most roads in the study area are located in valley floodplains crossed by numerous washes so that collection of large rain pools immediately adjacent to roadways occurs commonly. If insufficient rainfall had occurred so that anuran surface activity was initiated but no chorusing activity was apparent (i.e., no calling or breeding), we continued driving, scanning for and recording all anurans found on the road. When activity was relatively high (e.g., >20 anurans/km) and/or associated with an area of interest (e.g., historic or suspected locality for one of the target species), we recorded every individual anuran seen on the roadway (for a minimum of 1 km) until lack of moisture resulted in reduced anuran activity (e.g., <5 anurans/km).

Whenever we detected chorusing activity or pools of water along the roadway, we stopped and scanned the area adjacent to the roadway. If none of the target species were detected either visually or acoustically, we resumed the road survey. If target species were present, we attempted to record a series of voucher calls (see below) and collect a small series of voucher specimens ($N < 10$). Unfortunately, summer rainfall in south central Arizona was below average during the survey period, resulting in few actual breeding aggregations. All specimens are deposited in the ASU Vertebrate Collection.

Field Observations

Each target species possesses distinctive vocalizations. Advertisement calls were recorded in the field with a Marantz PMD 430 stereo recorder and Sennheiser ME 80 microphone with K3-U power module, or a Sony WM-D6C cassette recorder and Sony ECM-909 stereo microphone. Males generally ceased calling when they were approached (*Gastrophryne* and *Pternohyla* were easily disturbed); only if the observer remained relatively motionless would apparently normal calling behavior be resumed. Release calls were recorded either in the field or in the laboratory by gently compressing the sides of a male held between thumb and forefinger directly above a microphone (following Sullivan 1992). Only slight pressure was necessary to elicit a series of release calls. Cloacal temperatures were measured

with a Weber quick-recording thermometer within 5 sec of recording the final advertisement call or release call. Water and air temperatures were generally within 3°C of cloacal temperatures during field recordings.

Acoustic Analysis

Advertisement calls were digitized with a DATA Precision model 610 plug-in digitizer at a sampling rate of 10 kHz (Nyquist frequency = 5 kHz) and analyzed with a DATA Precision 6000 waveform analyzer. Release calls were digitized at a capture rate of 22 kHz on a Macintosh LC computer using a Farallon Corporation MacRecorder and analyzed with SoundEdit software (version 2.03). Call durations were measured to the nearest 0.01 sec with the Waveform analyzer (<2 sec) or with a stopwatch. Pulse rates of advertisement calls were measured over a 0.5-sec interval spanning the call midpoint; all pulses were counted to determine the pulse rate of release calls using the oscilloscope mode of SoundEdit. Dominant frequencies were estimated to the nearest 10 Hz over a 0.25-sec interval spanning call midpoints using the waveform analyzer. Neither advertisement nor release calls are frequency modulated to any large extent in any of the 3 anurans under study. For each male used in analysis of advertisement and release calls, mean values were generated for each of the 3 call variables from 3 or more calls.

Historic Distributions

We obtained specimen listings from the following institutions: American Museum of Natural History (AMNH), Arizona State University (ASU), Brigham Young University (BYU), California Academy of Sciences (CAS), Carnegie Museum of Natural History (CMNH), Los Angeles County Museum (LACM), Museum of Vertebrate Zoology (MVZ), University of Arizona (UA), University of Michigan Museum of Zoology (UMMZ), University of New Mexico (UNM), and United States National Museum (USNM). It is important to note that we examined only specimens deposited in the ASU collection and a portion of those housed at the USNM. We assume that anurans listed by the other institutions are correctly identified. Given that these 3 anurans are quite distinct from other Sonoran Desert forms and therefore unlikely to be misidentified, it seems reasonable to accept these listings in lieu of a physical

examination of all specimens. We did, however, obtain detailed information from collectors for any specimen collected outside or on the periphery of the range (e.g., San Xavier region).

RESULTS AND DISCUSSION

Bufo retiformis

Relative to other toads (genus *Bufo*) found in south central Arizona, *B. retiformis* possesses an unusually high-pitched, short-duration advertisement call, often described as an "insect-like buzz" (see Stebbins 1985, Hulse 1978). However, given similarities in advertisement calls of *B. retiformis* and *G. olivacea*, identification based on calls can only be confidently determined with analysis of signals in the laboratory (Sullivan unpublished data). On average, *B. retiformis* calls are longer ($\mu = 3.0$ sec, range = 2.0–4.3 sec at approximately 26° C body temperature) and lower in frequency ($\mu = 3112$ Hz) than calls of *Gastrophryne* (typically 1–2 sec duration at ≈ 4000 Hz).

HISTORIC DISTRIBUTION.—*Bufo retiformis* is known from west central Sonora and south central Arizona (Hulse 1978; Fig. 1). Since it was described in 1951, this anuran has been observed in Arizona at sites ranging from near San Cristobal Wash, just west of Organ Pipe Cactus National Monument, north to tributaries of Waterman Wash near Mobile, southeast to the vicinity of Tucson (San Xavier Mission), and southwest to the international border near Sasabe. Across this region it occurs in creosote flats, upland saguaro-palo verde associations, and relatively high-elevation (>900 m) desert grassland.

One historic locality deserves special discussion: southern Vekol Valley, Pinal County. At this site Jones et al. (1983) reported both *B. retiformis* and *B. debilis*. We have examined the single voucher specimens for *B. retiformis* (USNM 252797) and *B. debilis* (USNM 252776; SVL = 43 mm, reproductive female) and determined by comparison with juveniles in the ASU collection (ASU 23099–23102) that the putative *B. debilis* is not simply a juvenile *B. retiformis*. Using the morphometric methods proposed by Ferguson and Lowe (1969), we scored this individual close to *B. debilis* in all respects; hence, the *B. debilis* individual cannot be dismissed as a simple misidentification or hybrid. The presence of *B. debilis* well within the range of *B. retiformis* is especially prob-

lematic. No *B. debilis* have been recorded from appropriate habitat spanning the 240 km between Vekol Valley and the otherwise westernmost previous locality for this eastern relative of *B. retiformis* (near Benson, Arizona). Unfortunately, we were unable to survey Vekol Valley when conditions were suitable for anuran activity.

PRESENT DISTRIBUTION.—In 1993–94, we observed *B. retiformis* at or near most historic localities, except San Xavier and Vekol Valley, and at additional sites (Fig. 1). They were especially abundant along Indian Route (IR) 15, 0–40 km north of Quijotoa, associated with the Santa Rosa Wash floodplain. Surveys in which every anuran was identified along a roadway segment (1–65 km) revealed that *B. retiformis* constituted up to 63% of all anurans sighted on this route (Table 1), whereas they were absent or composed a small proportion (<1%) of total anurans sighted on roadways on the periphery of their distribution near Mobile and Sasabe (Table 1). Similarly, this toad was not abundant along State Route (SR) 85 near Organ Pipe Cactus National Monument. During 1993 and 1994 we never observed this species on SR 85 or SR 86 in this westernmost portion of the range. Philip Rosen (personal communication) has observed only a few *B. retiformis* near the international border, and a number of individuals near Why, Arizona, during the course of extensive fieldwork near Organ Pipe Cactus National Monument over the past 6 yr.

Contrary to the suggestion of Hulse (1978; see also Nickerson and Mays 1968), *Bufo retiformis* does not appear to be expanding its range northward into areas of agricultural activity (e.g., southern Pinal County). We conducted many surveys in southern Pinal County: south of Stanfield and south of Arizona City, 2 areas directly north of known localities for *B. retiformis* (Fig 1). We also extensively surveyed the Avra Valley region, Pima County, immediately west of Tucson, and the vicinity of Mobile, Maricopa County. These habitats are similar to areas inhabited by *B. retiformis* directly to the south or west, except that agricultural activity is relatively higher in these areas. It appears that *B. retiformis* is less common on the periphery of its range: near Organ Pipe Cactus National Monument in the west, near Mobile in the north, and in Altar Valley in the east.

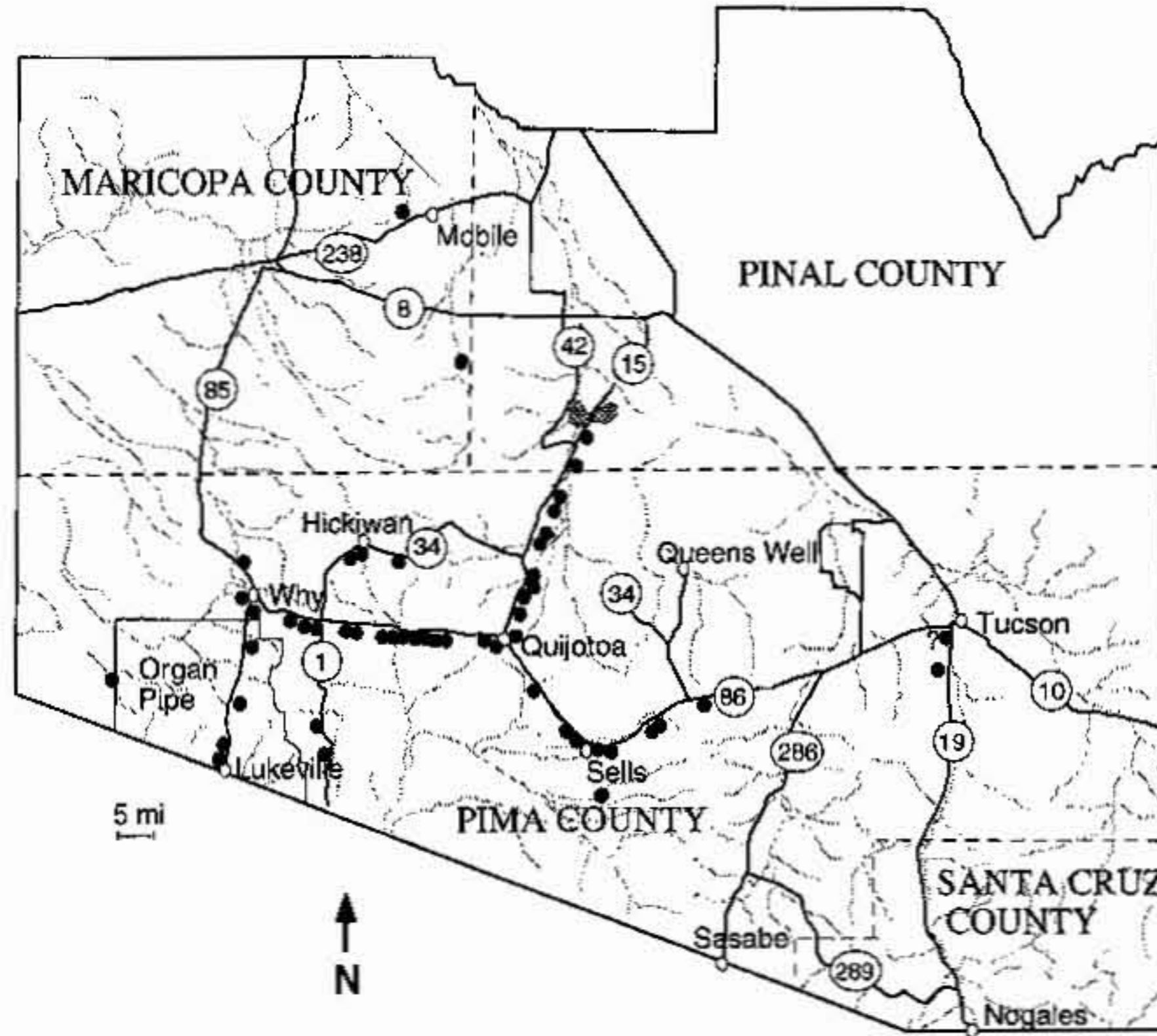
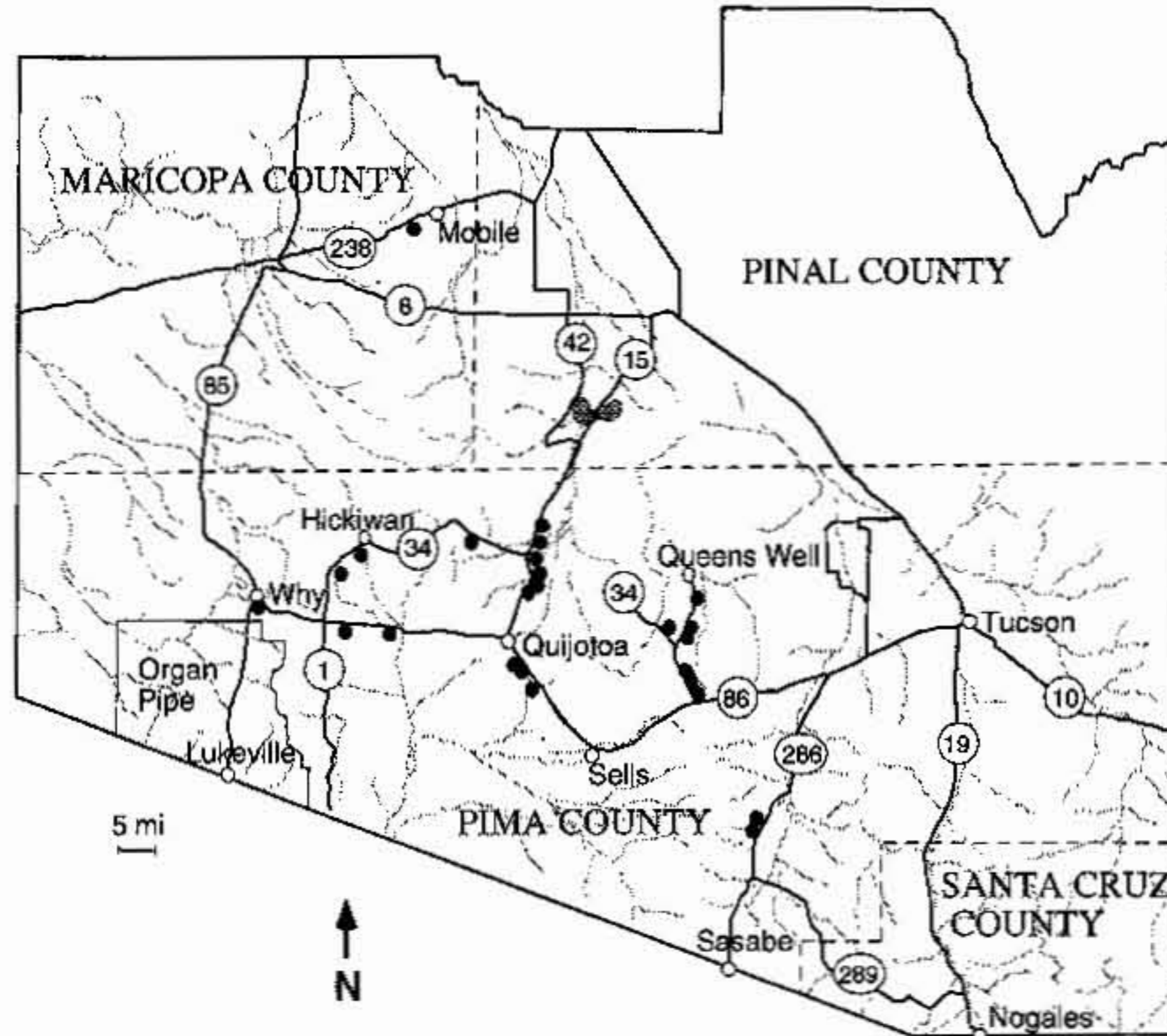
a) Historic collecting localities for *Bufo retiformis* in south central Arizona.b) Recent collecting localities for *Bufo retiformis* in south central Arizona.

Fig. 1. Map of a) historic distribution (•) and b) present distribution (•) of *Bufo retiformis* in south central Arizona.

BREEDING ACTIVITY.—Like many explosive breeding desert anurans, *B. retiformis* will take advantage of a variety of water sources for reproduction. We observed chorusing activity in cattle tanks and roadside pools associated with washes. We observed *B. retiformis* breeding in the same pool with all other explosive breeding anurans that occur in south central Arizona:

B. alvarius, *B. cognatus*, *B. punctatus*, *Gastrophryne olivacea*, *Pternohyla fodiens*, *Scaphiopus couchii*, and *Spea multiplicata*. We never observed *B. retiformis* breeding in the absence of other anurans—minimally, *B. cognatus* and *S. couchii* bred sympatrically with *B. retiformis*.

Male *B. retiformis* typically call positioned beneath vegetation (e.g., small shrubs or grass),

TABLE 1. Numbers of anurans individually identified on road surface over a specified distance. Bal = *B. alvarius*, Bco = *B. cognatus*, Bpu = *B. punctatus*, Bre = *B. retiformis*, Sco = *Scaphiopus couchii*, IR = Indian Route, SR = State Route, MM = mile marker.

Date	Location (approximate)	Survey distance (km)	Species					Total
			Bal (%)	Bco (%)	Bpu (%)	Bre (%)	Sco (%)	
7/18/94	SR 286	40	31 (33)	13 (14)	—	—	49 (53)	93
7/28/94	Arizona City	24	4 (40)	2 (20)	—	—	4 (40)	10
7/29/94	SR 286	72	13 (18)	13 (18)	5 (7)	—	39 (56)	70
8/7/94	Mobile	25	5 (18)	—	3 (11)	1 (3)	19 (68)	28
8/8/94	SR 286	24	3 (23)	4 (31)	—	—	6 (46)	13
8/8/94	Mobile	30	10 (14)	4 (6)	5 (7)	—	51 (73)	70
8/13/94	IR 15, MM 11	4.8	1 (3)	1 (3)	1 (3)	9 (28)	20 (63)	32
8/15/94	IR 15, MM 11	3.4	2 (25)	—	—	5 (63)	1 (13)	8
9/10/94	Stanfield	5.3	64 (75)	9 (10)	1 (1)	—	11 (13)	85

1–5 m from the water's edge. Amplexus is initiated on land with the typically larger female carrying the male to water for oviposition. In high-density aggregations, satellite males can be common—we saw as many as 3 non-calling males near 1 calling male.

Chorusing males and amplexing pairs were observed on only 4 occasions. Three breeding aggregations along IR 15 were relatively large and located at sites used regularly in the past (e.g., 1984, 1986, 1988; Sullivan and Bowker unpublished). At mile marker (MM) 18.7 on IR 15 north of Quijotoa, a large aggregation formed in a shallow roadside pool (8/9/93). Unfortunately, direct counts of all individuals present were not possible due to restricted property access, but complete counts of all males and females along an open section of the pool shoreline (23 calling and satellite males, 5 females in 75 m) allow a rough minimum estimate of >200 males and females for the entire pool (~600 m circumference). Observations at a 2nd site that same night, a cattle tank (~25 × 50 m) near MM 8.5, north of Quijotoa, indicate a thriving population in spite of hybridization with *B. punctatus* (see below). On the 1st night (8/9/93) following heavy rainfall in this area, we counted 20 male *B. retiformis* at 0300, calling with numerous *B. alvarius*, *B. cognatus*, and *B. punctatus*. On the following night (8/10/93), approximately 40 male *B. retiformis* were observed, in addition to a minimum of 5 pairs in amplexus. A 3rd

breeding aggregation (8/25/94) at a roadside pool (~50 × 25 m) at MM 11 on IR 15 west of Santa Rosa comprised 19 calling males and 5 amplexing pairs (direct count of all individuals). In contrast to these relatively vigorous aggregations, only 6 males and a single female were observed at a "first-night" chorus (8/20/93) in a large cattle tank (~25 × 75 m) near Gunsight Wash along SR 85.

HYBRIDIZATION WITH *BUFO PUNCTATUS*.—Bowker and Sullivan (1991) documented a naturally occurring hybrid between *B. retiformis* and *B. punctatus*, and we observed 3 additional hybrids during our investigation (all in August 1993). These hybrids were observed along IR 15, 10–20 km north of Quijotoa. Hybrids are intermediate to the 2 parental forms and unlikely to be confused with any other anurans in the vicinity. Given the apparent rareness of hybrids, it is unlikely that they present a significant concern for the population status of either parental form.

Hybridization between *B. punctatus* and *B. retiformis* is somewhat surprising given dramatic differences in their advertisement calls and habitat preferences (Ferguson and Lowe 1969). Three factors may facilitate hybridization between *B. punctatus* and *B. retiformis* along IR 15 north of Quijotoa. First, along IR 15 we observed relatively high numbers of *B. retiformis* compared to *B. punctatus*, and we also noted satellite males near calling males in these aggregations. Male mating tactics such

as active searching and satellite behavior can increase the probability of heterospecific crosses since these tactics subvert active choice by females. Second, although *B. retiformis* is typically found in desert flats and *B. punctatus* generally occurs in rockier, upland regions, the "hybrid zone" along IR 15 (MM 6–12) represents a transition between lowland (Lower Colorado River Subdivision) and upland (Arizona Upland Subdivision) desert habitats that would allow coexistence of both species. Third, habitat modification at the site, namely, road construction and development of cattle tanks, may overcome ecological separation between the species and provide opportunities for hybridization.

Gastrophryne olivacea

As noted above, the advertisement call of *G. olivacea* can be confused with *B. retiformis*. In the hand, this small, narrow-mouthed toad cannot be confused with any other species found in Arizona (Nelson 1972a, 1972b, 1973, Stebbins 1985). Identification based on calls (insect-like buzz) alone must be corroborated by laboratory acoustic analysis.

Although Lowe (1964) listed *G. carolinensis* from the mountains near Nogales, Arizona, Nelson (1972a, 1972b) showed that these individuals do not differ significantly from nearby populations of *G. olivacea* from lower-elevation sites. Having examined specimens from throughout the range in Arizona, we concur with Nelson that only a single taxon occurs north of the international boundary.

HISTORIC DISTRIBUTION.—The range of *G. olivacea* largely overlaps that of *B. retiformis* (Fig. 2), except in Santa Cruz County (e.g., near Pena Blanca) where *Gastrophryne* occurs farther east. Of the 3 anurans surveyed, this species occurs in the widest variety of habitats in Arizona, ranging from low-elevation creosote flats through grasslands to oak-woodland communities near Ruby, Arizona (>1200 m).

Wake (1961) reported calling *G. olivacea* 4.8 km southeast of Ajo. Because no individuals were visually confirmed and because of the difficulty of identifying this species by call, we are inclined to discount the record.

PRESENT DISTRIBUTION.—In 1993–94 we observed *G. olivacea* at most historic localities except those on the eastern margin of the study area (San Xavier and vicinity of Pena Blanca), and at some new sites (Fig. 2). We

observed a small chorus near Lukeville, just north of the international boundary, a site that extends the range of *Gastrophryne* approximately 58 km southwest of the previous westernmost locality (San Simon Wash, SR 86) in the United States. Philip Rosen (personal communication) suggests that *Gastrophryne* is more abundant in Mexico to the south and southeast of Lukeville. The absence of previous distributional records from Organ Pipe Cactus National Monument substantiates the notion that *G. olivacea* reaches its northwestern range limit in this area.

We were unable to document *G. olivacea* anywhere along SR 286 (Altar Valley, Buenos Aires Refuge) in spite of apparently adequate habitat and the presence of *G. olivacea* to the east. Philip Rosen (1994 personal communication) observed a number of *G. olivacea* breeding choruses in southwestern Santa Cruz County, just east of the Buenos Aires Refuge boundary, during summer 1994. Hence, this species likely occurs in the area but, like *B. retiformis*, may be less abundant along SR 286. We did not find *G. olivacea* in the vicinity of San Xavier Mission or along SR 289, although we visited these sites after rainfall on several occasions. Our failure to document *Gastrophryne* in areas with appropriate habitat may be an artifact of its secretive habits (i.e., individuals may not come on road surfaces) and small size (i.e., they are difficult to detect when on a road).

BREEDING ACTIVITY.—*Gastrophryne olivacea* are usually well concealed in vegetation when calling and possess a call that is extremely difficult to localize. They call next to water sources or from floating vegetation. Male satellite activity was not observed. Although *G. olivacea* has been observed in choruses with all other sympatrically breeding anurans (see above listing under *B. retiformis*), on many occasions we observed it in large, relatively monotypic aggregations (e.g., MM 26.7 and 35, IR 15). In these areas *Gastrophryne* often breeds in dense stands of mesquite shrubs growing in the floodplain of Santa Rosa Wash.

Choruses of *Gastrophryne* are easily detected, and we were led to a number of new *Gastrophryne* localities by their distinctive vocalizations. Because of their secretive nature, we never observed pairs in amplexus, and thus no definitive estimates of population size were obtained for breeding choruses of *G. olivacea*.

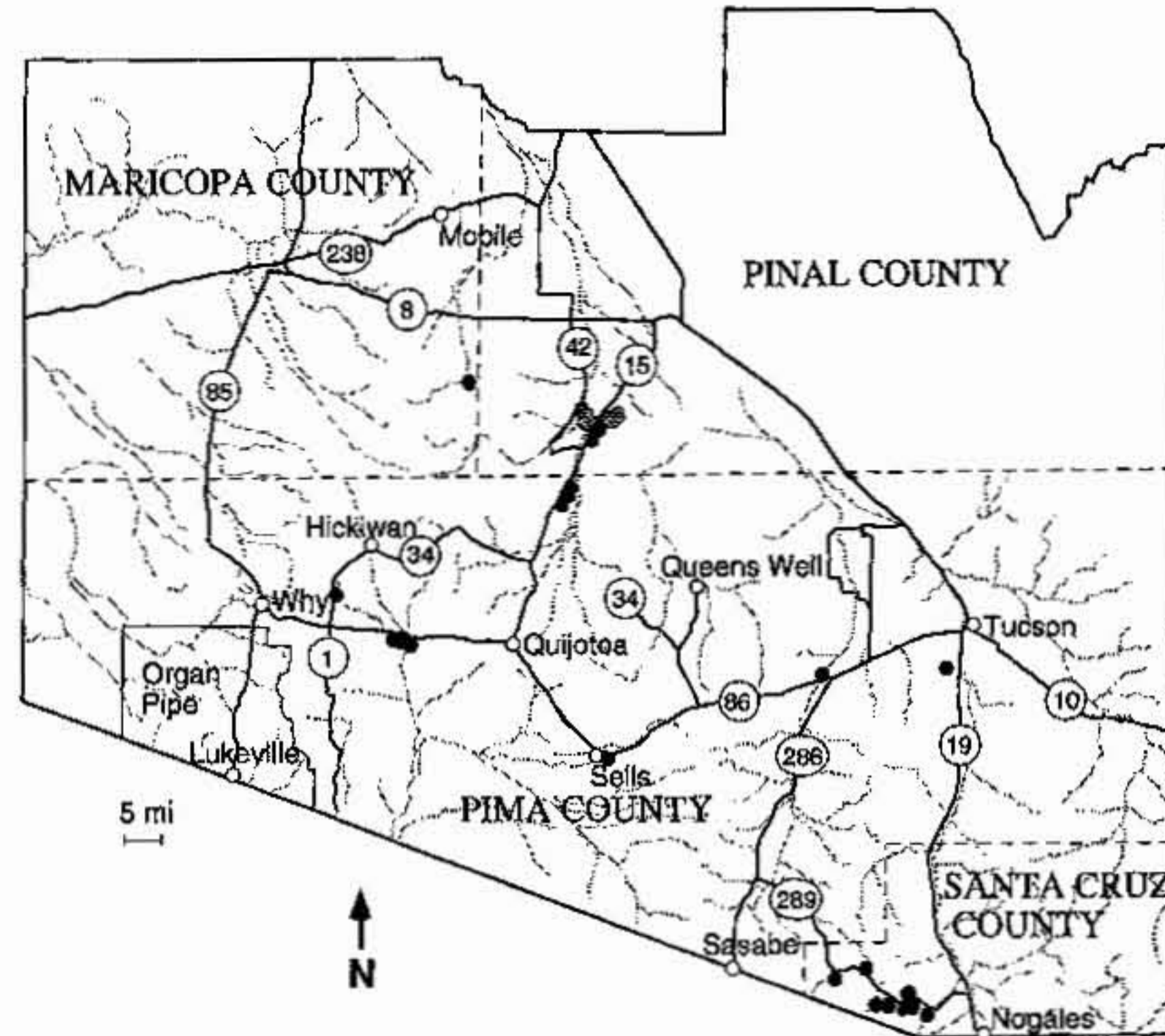
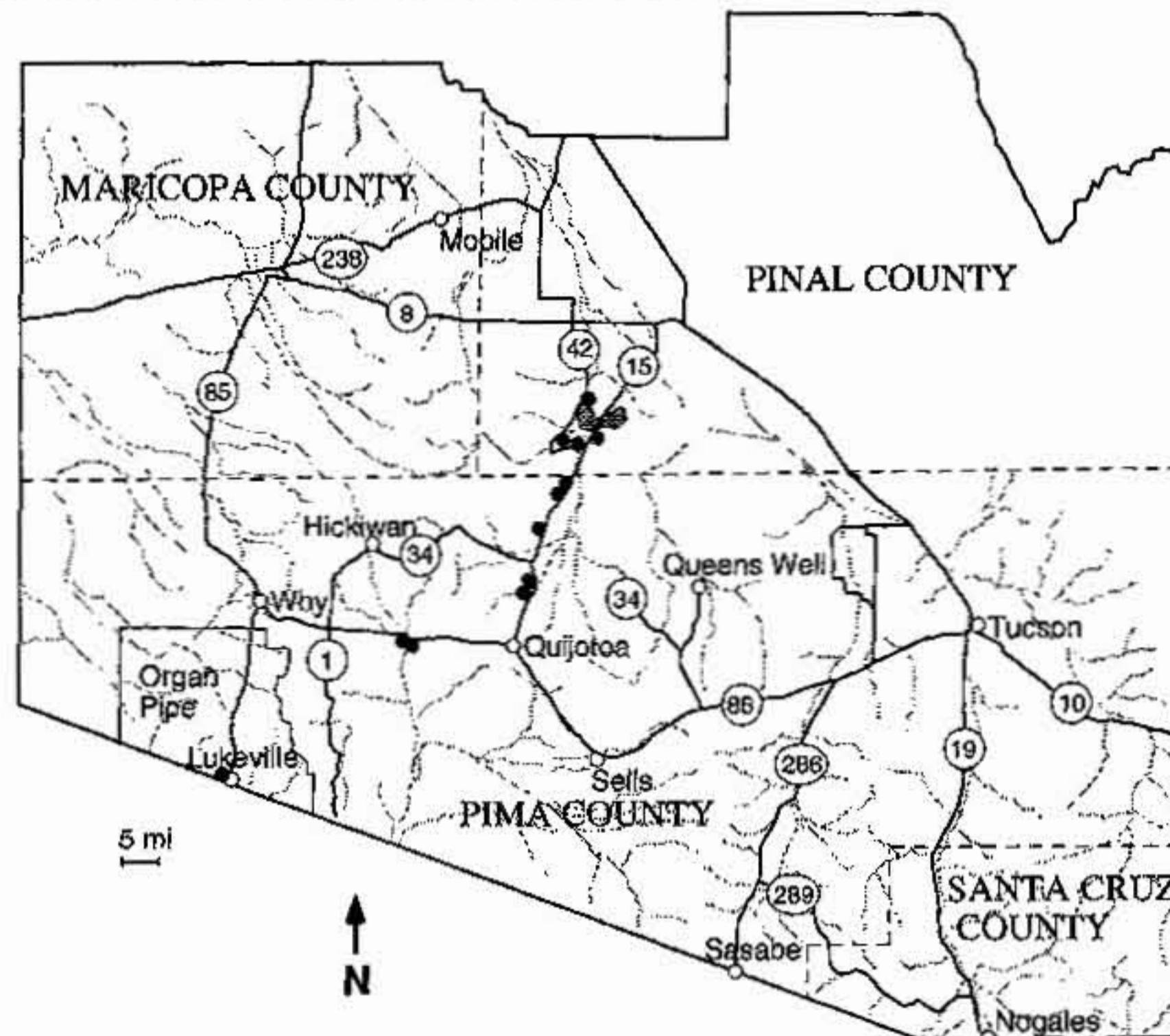
a) Historic collecting localities for *Gastrophryne olivacea* in south central Arizona.b) Recent collecting localities for *Gastrophryne olivacea* in south central Arizona.

Fig. 2. Map of a) historic distribution (•) and b) present distribution (•) of *Gastrophryne olivacea* in south central Arizona.

By walking the perimeter of rain-formed pools, we obtained rough estimates of >200 calling males at 2 sites along IR 15, 43 and 56 km north of Quijotoa, respectively, on recent (8/9/93) and previous surveys (1984; Sullivan and Bowker unpublished). Unfortunately, since these pools contained considerable vegetation (mesquite shrubs, grass), chorus sizes can only be considered approximate (individual toads were not visually verified). By contrast, at Luke-

ville (8/9/94) only 5 calling males were present in a small pool (5 × 10 × 0.25 m). Rain had fallen the previous 2 nights (8/7–8/8), and several small egg masses were observed.

Pternohyla fodiens

The advertisement call of *Pternohyla fodiens* is a distinctive "wonk" repeated at a relatively high rate (2/sec: "wonk-wonk-wonk . . .," etc; see Trueb 1969). Males also produce a call,

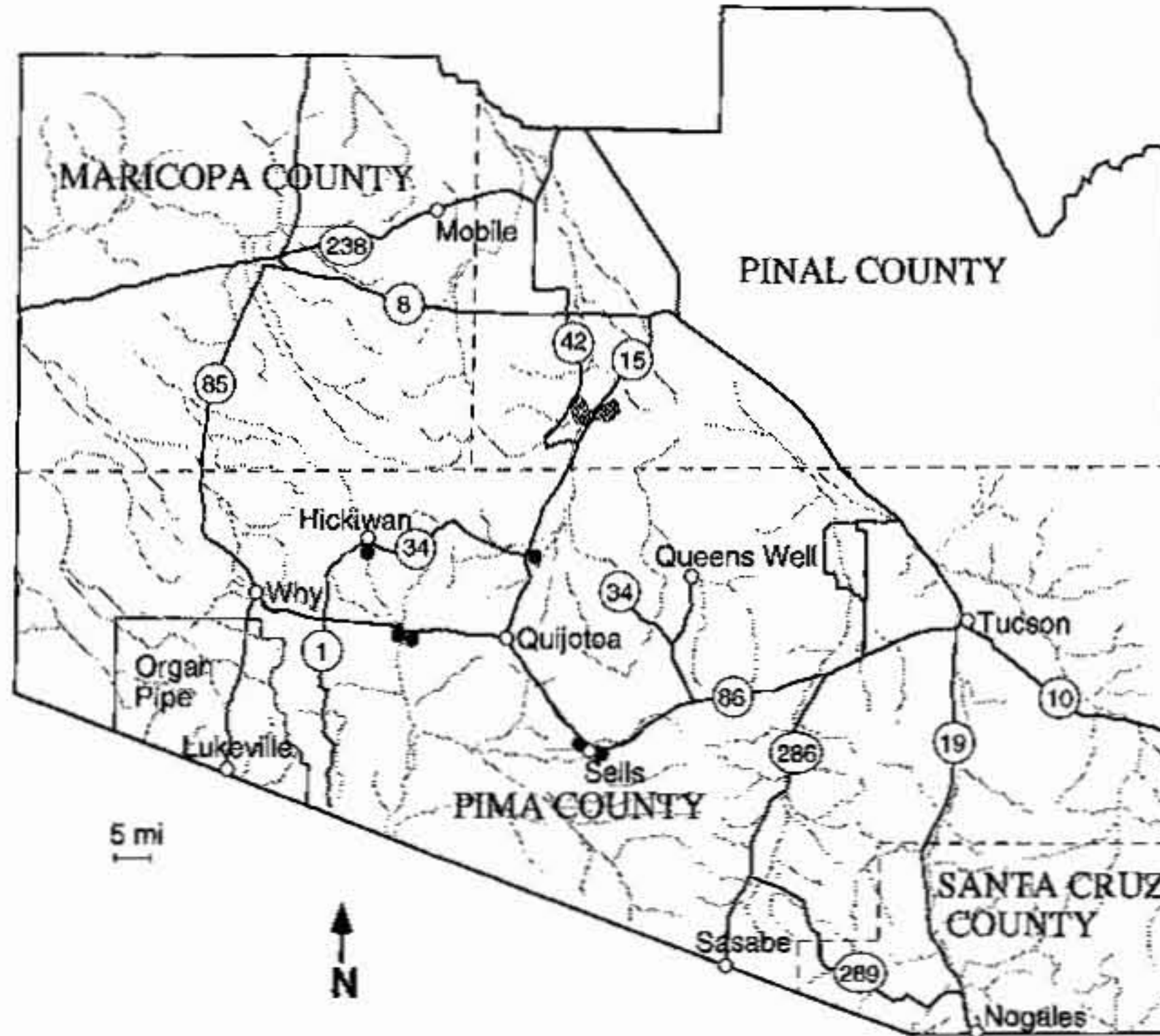
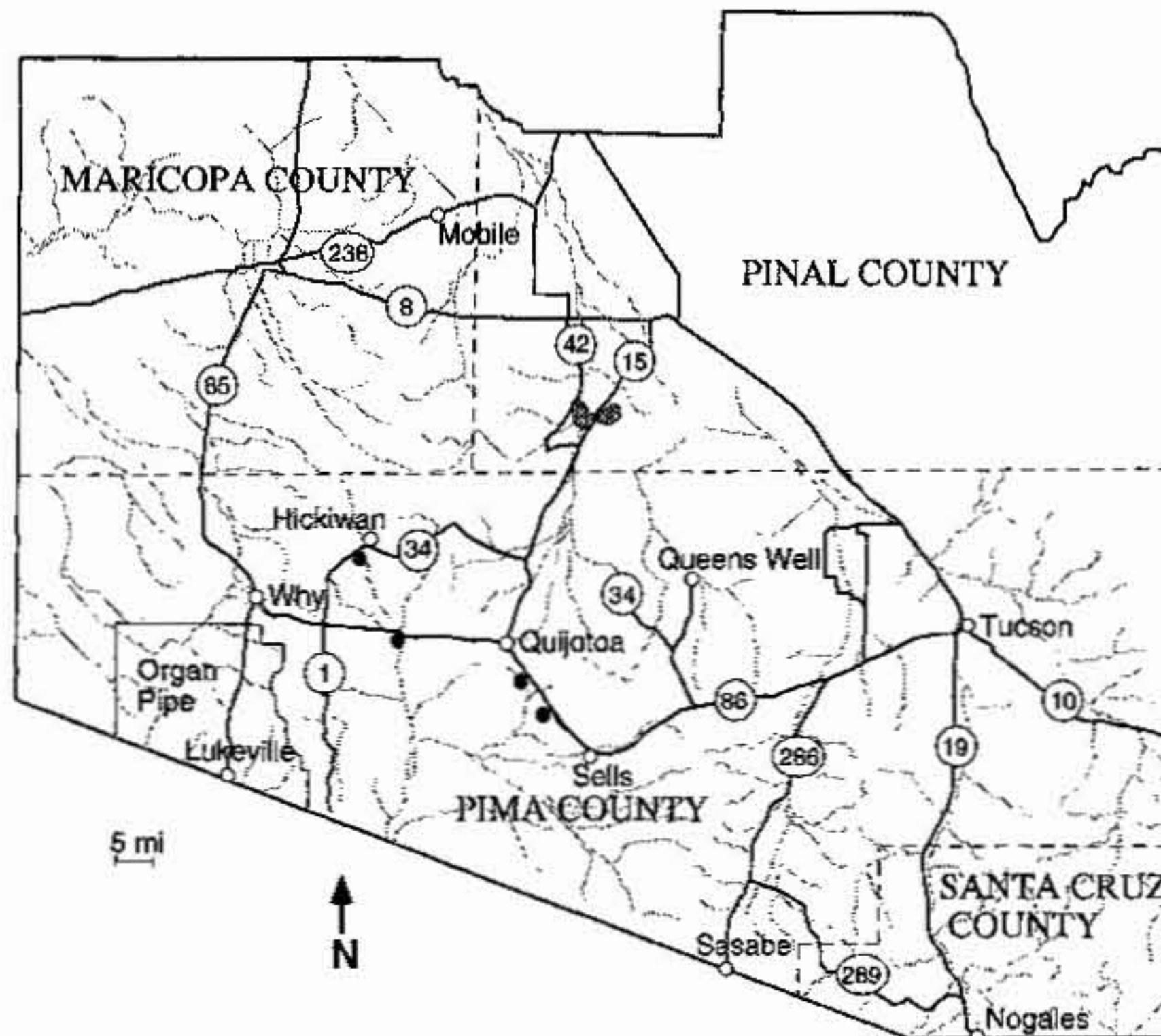
a) Historic collecting localities for *Pternohyla fodiens* in south central Arizona.b) Recent collecting localities for *Pternohyla fodiens* in south central Arizona.

Fig. 3. Map of a) historic distribution (•) and b) present distribution (•) of *Pternohyla fodiens* in south central Arizona.

which, based on similarities with other hylids, can be tentatively classified as a territorial call. This putative territorial call sounds much like the advertisement call of *Pseudacris triseriata* or the sound of a finger sliding across a comb.

HISTORIC DISTRIBUTION.—This anuran has been observed at a few sites (Fig. 3). All localities but Santa Rosa Wash are associated with washes that flow south toward Mexico: San Simon Wash, and its 2 largest tributaries, Hicki-

wan and Sells washes. Randy Babb (personal communication) has heard the distinctive vocalization of *Pternohyla fodiens* many times and visually identified at least 1 individual approximately 16 km north of Quijotoa, west of IR 15, in the floodplain of Santa Rosa Wash.

PRESENT DISTRIBUTION.—In 1993–94 we observed *P. fodiens* at most historic localities except Santa Rosa Wash and the vicinity of Sells, and at some additional sites (Fig. 3).

More than the other target species, *P. fodiens* is found in association with washes. The 2 new localities we documented are both associated with small tributaries of Sells Wash, a tributary of San Simon Wash.

During the preparation of this report, Thomas R. Jones and Ross J. Timmons (personal communication) found a single male *P. fodiens* near Santa Rosa Wash, 1 km north of the Pinal County line and west of IR 15 (12 July 1995). This record confirms the presence of *P. fodiens* in Santa Rosa Wash, well north of the San Simon Wash system.

Pternohyla fodiens is only rarely found on road surfaces, although specimens can be taken near washes when roads are wet (e.g., SR 86 at San Simon Wash). Similar to *Gastrophryne*, *Pternohyla* can be easily missed unless chorus activity is underway when a survey is conducted. Because of their extremely explosive breeding habits and the lack of sufficient rainfall near Sells during the survey period, it is not surprising that we observed no *Pternohyla* at the historic localities along Sells Wash near SR 86.

BREEDING ACTIVITY.—We observed breeding aggregations of *Pternohyla fodiens* only in rain-formed pools associated with washes. Calling males are always in or near water, and of the 3 survey anurans *Pternohyla* seems more dependent on heavy rainfall to initiate breeding activity. This species appears to exhibit the most explosive mating system of the 3 species. We never observed *Pternohyla* chorusing more than 36 h after rainfall; by contrast, both *Gastrophryne* and *Bufo* were observed in chorus activity 1–4 nights following rainfall.

The only significant *Pternohyla* chorusing that we observed occurred near Hickiwan (7/13/93) and San Simon Wash (7/13/93). Although direct counts were not possible, estimates from chorusing intensities suggest that dozens, if not hundreds, of calling males may have been present at San Simon Wash along SR 86; however, only a single pair in amplexus was observed. Large aggregations of *Pternohyla* have been observed at these sites regularly over the past 30 yr (Sullivan and Bowker unpublished).

SUMMARY

Our survey indicates that all 3 target species are present at most historic localities in south

central Arizona. We documented range extensions to the northwest and southeast for *B. retiformis* (Mobile/SR 286) and to the southwest for *Gastrophryne olivacea* (Lukeville). These forms probably occur at all historic localities, since our inability to verify their presence at some sites undoubtedly resulted from the absence of sufficient rainfall. It is critical to note that our survey methods, although allowing rapid coverage of a relatively large area, were limited by unpredictable rainfall and the secretive nature of the target species (especially *Pternohyla* and *Gastrophryne*). Unless chorusing activity was underway when we visited an area, the presence of any of the 3 forms may have been overlooked. In the absence of chorusing activity, *Bufo retiformis* was the only target species regularly found on road surfaces.

Minimally, the presence of these anurans at most historic localities suggests no widespread decline as experienced by other anuran amphibians in the United States (e.g., ranid frogs of the Southwest; Michael Sredl personal communication). Future work should address estimation of population levels through mark-recapture methods in conjunction with intensive monitoring of single sites throughout as many consecutive activity periods (June–September) as possible. An understanding of factors contributing to variations in species abundance will require long-term study.

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APPENDIX I

Specimen numbers for historic collecting localities for *Bufo retiformis*, *Gastrophryne olivacea*, and *Pternohyla fodiens*. Institutional abbreviations: AMNH = American Museum of Natural History, ASU = Arizona State University vertebrate collection, BYU = Brigham Young University collection, CAS = California Academy of Sciences, CMNH = Carnegie Museum of Natural History, LACM = Los Angeles County Museum, MVZ = Museum of Vertebrate Zoology, UAZ = University of Arizona, UMMZ = University of Michigan Museum of Zoology, UNM = University of New Mexico, USNM = United States National Museum.

Bufo retiformis: AMNH 59189, 60671, 85357-65, 91953-54, 102234-36; ASU 3298-3300, 3894-3902, 3942-48, 8002, 8004, 8005, 22775-76, 23099-102, 23252, 24038-39, 24273-74, 25552-53; BYU 42119; CAS 91501-04, 94390-95, 98055-56, 188354-55; CMNH 51562, 53841-42, 53855, 63520, 89782-95; LACM 26086-88, 64180-84, 88380-400, 91833, 105719, 115266-314, 123234-41, 137788-89; MVZ 71906-07, 73751-52, 74206-32, 76620-28, 81269, 139130, 180219-22, 180358-59; UAZ 12369-75, 14848-49, 25847-48, 31381, 43011; UMMZ 133460, 136395, 134077; UNM 30993-995, 31268, 40207, 41686-87; USNM 226443-45, 245988, 252797, 322966.

Gastrophryne olivacea: AMNH 88986, 91971-80, 119746; ASU 14014, 22059-60, 22224-25, 22969-70, 22771-74, 23095, 23411, 24259-60, 25664-66; CMNH 63138-39; LACM 26576-81, 91896, 115511, 112480, 123293; MVZ 49479-504, 58922, 72304-05; UAZ 26993-96, 29101-04, 29107, 42187-91, 38181, 35163-64, 38179, 38200-01, 38180, 38197-99, 29027; USNM 252817; UMMZ 136400, 75737-38, 75753, 92300.

Pternohyla fodiens: AMNH 91964-70, 95147; ASU 3301, 13952-68, 22777-80, 24276, 25556-61; CAS 91505; CMNH 63188-89; LACM 90170-82, 115447-75; MVZ 71905, 73747-48, 80104-21, 81271, 178447, 76629-33; UNM 40201, 40204.

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