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Domestic water buffaloes: an unexpected basking support for two sympatric freshwater turtles, *Emys orbicularis* (Linnaeus, 1758) and *Mauremys rivulata* (Valenciennes, 1833) in Türkiye

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Commensalism is the association between two species with benefits to one and neither benefit nor harm to the other (Mikula et al., 2018; Mathis and Bronstein, 2020). Although symbiotic interactions are widespread among plants and animals, these interactions are less frequently documented for amphibians and reptiles than in other vertebrates (Dickman, 1992). The best-known such relationships include the mutualistic relationship between Galapagos Giant Tortoises (*Chelonoidis niger*) and the finches *Geospiza fuliginosa* and *G. fortis* in the Galapagos Islands, where both species benefit from the removal of ticks and parasites found on the tortoises (MacFarland and Reeder, 1974; Brooks, 2012). Interactions between amphibians and reptiles and mega-mammal species are relatively rare compared to those among other groups of vertebrates. Examples of this kind of interaction include Marsh Frogs (*Pelophylax ridibundus*) foraging for insects and parasites on Domestic Water Buffalo, *Bubalus bubalis* (Zduniak et al., 2017) and Helmet Turtles (genus *Pelomedusa* sp.) removing parasites from Cape Buffalo (*Syncerus caffer*) (Kerley, 2021).

Reptiles are ectotherms that rely on behavioural and/or physiological mechanisms to regulate their body temperature (Huey, 1982; Nowakowski et al., 2018; Chessman, 2024). Basking is a common behaviour in reptiles, particularly in turtles, who gain many advantages: it helps regulate body temperature, improve digestion, support gonadal recrudescence, synthesize vitamin D, remove parasites and, accelerate egg development (Auth, 1975; Avery, 1982; Chessman, 2024). Basking sites, both on land and in water, are generally chosen in are semi-open areas to allow thermoregulation, while the vegetation offers natural protection against predation (Capula et al., 1994; Chessman, 2024). In the absence of suitable basking sites, turtles may seek alternatives through commensal and/or mutualistic associations. Here, we describe the first case of a commensal interaction between two turtle species, the European Pond Turtle (*Emys orbicularis*) and the Western Caspian Terrapin (*Mauremys rivulata*) with domestic water buffalo (DWB).

Locality. Observations were made in a pond located on the southwestern Black Sea shoreline in Kırklareli Province, northwestern Türkiye (41.6700°N, 28.0943°E). According to the Köppen Climate Classification, the region has a Csa-type Mediterranean climate, characterized by mild winters and very hot, dry summers (Beck et al., 2018). The pond is situated in a wind farm and was formed after roadwork was carried out in 2002. The open water surface of the pond, which is a temporary wetland, spans approximately 0.5 ha and has an average depth of 1.5 m. The pond's sediment is muddy, and the water is consistently turbid. The pond is surrounded by willow trees (*Salix* sp.) and oak forest (*Quercus* sp.) dominated by shrubs (Fig. 1). The emergent aquatic vegetation in the pond includes Water Mint (*Mentha aquatica*) and reeds (*Phragmites* sp.). DWBs use the pond for wallowing and feeding (Fig. 1). The average size of a DWB herd using the pond is 9 ± 4.6 individuals (mean ± standard deviation).

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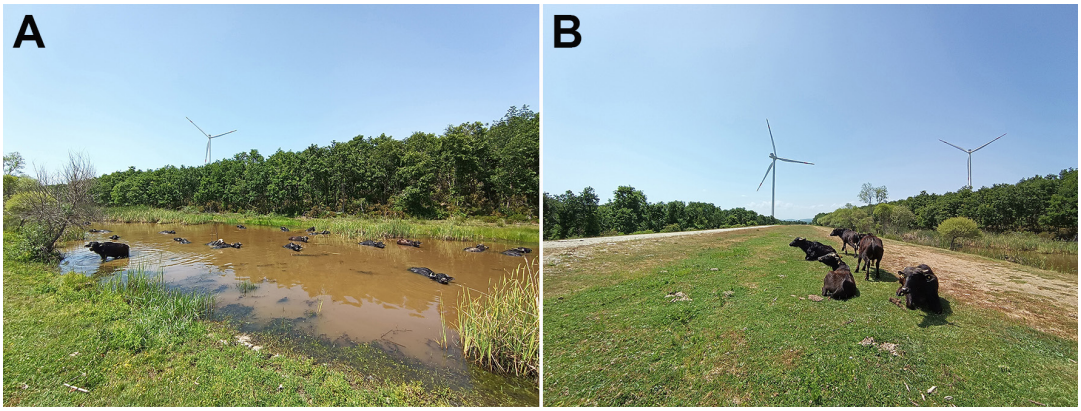

Figure 1. General view of the study area with Domestic Wild Buffaloes (*Bubalus bubalis*) in Kırklareli Province, Türkiye. (A) The temporary pond with a group of buffaloes. (B) The edge of the pond with access road into the wind farm. Photos by Cem Akın.

Data collection. Observations were made opportunistically while monitoring bird species in the study area. Field monitoring was carried out between May and August in 2020–2022 during 14 sessions (four days in 2020, one day in 2021, nine days in 2022). Observations were conducted from 07:00–17:00 h with binoculars. The average temperature on the observation days was 24.6 ± 1.8°C with wind speed < 15 km/h and without rainfall. We systematically recorded all basking turtles on the backs of DWBs together with the following environmental variables: date, starting and ending time of the basking behaviour, behaviour type (basking, feeding or other), location on the buffalo (middle, front, or tail region), age of DWB (adult or young), sex of DWB, DWB numbers in the herd, number of basking animals on each DWB, reason for termination of activity (host movement, basking animals' own activity, other animals interrupting, or climbing failure).

Basking on DWBs. Four amphibian (two salamanders, two frogs) and four reptile (two turtles, two snake) species were observed in the pond. Basking on DWBs was observed for three of these, namely the Marsh Frog, Western Caspian Terrapin, and European Pond Turtle (Fig. 2). The five species recorded in the pond but not observed to interact with DWBs included Oriental Treefrogs (*Hyla orientalis*), Common Toads (*Bufo bufo*), Balkan Crested Newts (*Triturus ivanbureschi*), Dice Snakes (*Natrix tessellata*), and Grass Snakes (*Natrix natrix*).

A total of 65 basking events were recorded, including ten failed climbing attempts (Table 1). We recorded 41 instances of basking by European Pond Turtles, 18 by Western Caspian Tortoises, five by Marsh Frogs,

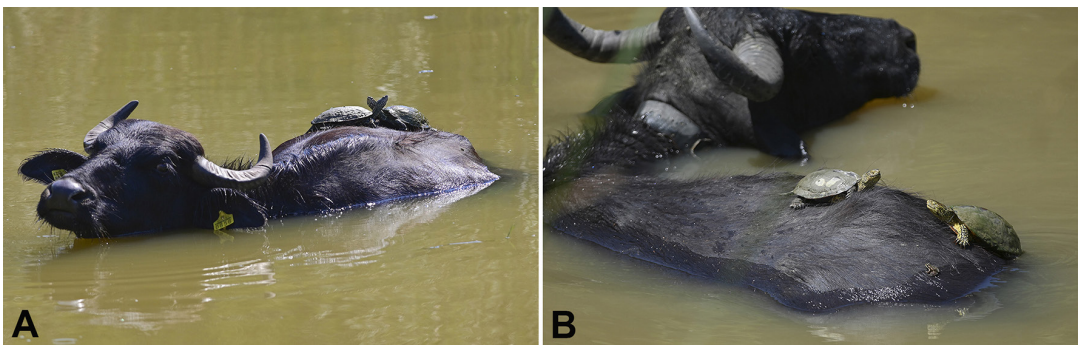

Figure 2. Interactions between Domestic Wild Buffaloes (*Bubalus bubalis*), turtles, and frogs in Kırklareli Province, Türkiye. (A) Two Western Caspian Turtles (*Mauremys rivulata*). (B) Two European Pond Turtles (*Emys orbicularis*) and a Marsh Frog (*Pelophylax ridibundus*). Photos by Cem Akın.

Table 1. Summary table for observed interactions between turtles, frogs, and Domestic Wild Buffaloes (DWBs) at a temporary pond in Türkiye in 2020–2022. Numbered columns list the number of DWBs with frogs or turtles (1), with *Emys orbicularis* (2), with *Mauremys rivulata* (3), and with *Pelophylax ridibundus* (4). Additional listed variables are air temperature (AT) in °C, wind speed (WS) in km/h, and average total time spent basking on a DWB (TB) in minutes.

Date	1	2	3	4	AT	WS	T_B
20 May 2020	5	2	0	3	23	5	12.8
15 Jul 2020	6	6	0	0	26	8	10.2
20 Jul 2020	2	1	1	0	27	6	9.5
29 Jul 2020	1	1	0	0	29	8	5.0
25 Jun 2021	2	1	1	0	26	4	3.7
29 May 2022	6	3	3	0	22	7	14.3
01 Jun 2022	7	6	0	1	23	6	4.0
13 Jun 2022	7	4	3	0	23	13	7.6
16 Jul 2022	5	4	1	0	26	6	6.0
23 Jul 2022	2	0	2	0	28	3	7.0
26 Jul 2022	1	1	0	0	26	6	10
27 Jul 2022	3	2	0	1	26	7	18.7
29 Jul 2022	8	5	1	2	25	10.9	6.8
08 Aug 2022	2	0	2	0	27	15	30.5

and one by an unidentified turtle. Since individuals were not marked, we do not know how many individuals were involved in these observations, nor the proportion of individuals in this population that used the backs of the DWBs to thermoregulate. The majority of observations (48 of 65) involved a single species basking on a particular DWB (e.g., Fig. 2A). On seven occasions we observed two species on a DWB (e.g., Fig. 2B), and on one occasion there were three species. A table with our complete records can be found at http://doi.org/10.6084/m9.figshare.25772172.

All observed animals were basking on adult DWBs, with the exception of one *Emys orbicularis* that was basking on a subadult DWB. The average duration of basking on the backs of the DWBs was 10.6 ± 8.4 min. The reasons for termination of basking on DWBs were primarily related to the host animal deciding to move (58.5%), followed by decisions made by the basking animal (23.1%), failing to climb (13.8%), and interruptions by other animals (4.6%).

Discussion

Our observations provide a new example of commensal interactions for amphibians and reptiles (Fig. 3). In the past, interactions between large herbivores and reptiles were more commonly reported as prey-predator relationships (Adame et al., 2018), and there is only limited documentation of commensalism or possible mutualism between amphibians, reptiles, and buffaloes. In these cases, frogs and turtles are mainly listed as feeders on host species parasites (Krawchuk et al., 1997; Zduniak et al., 2017; Kerley, 2021).

Our observations showed that the turtles did use other basking sites, such as vegetation, rocks, tree branches, and banks located at the edge of the pond. However, these other basking options were only rarely used when buffaloes were in the pond. Despite these observations, there is a lack of quantitative data to support any preference. Further research is needed to understand whether aquatic turtles in this pond preferred to thermoregulate on DWBs and why.

Large herbivores are often recognized as a management tool for the conservation of natural areas and the beneficial impacts of grazing on biodiversity (Michels et al., 2012; Soliman, 2018; Mesléard, 2023). However, in some cases too many large grazers can have a negative impact, by degrading wetlands and injuring turtles (e.g., Olivier et al., 2010; Ficheux et al., 2014). The European Pond Turtle is known to use a large diversity of basking sites, including reeds, logs and branches, banks, other emergent aquatic vegetation, and stones that emerge from the water

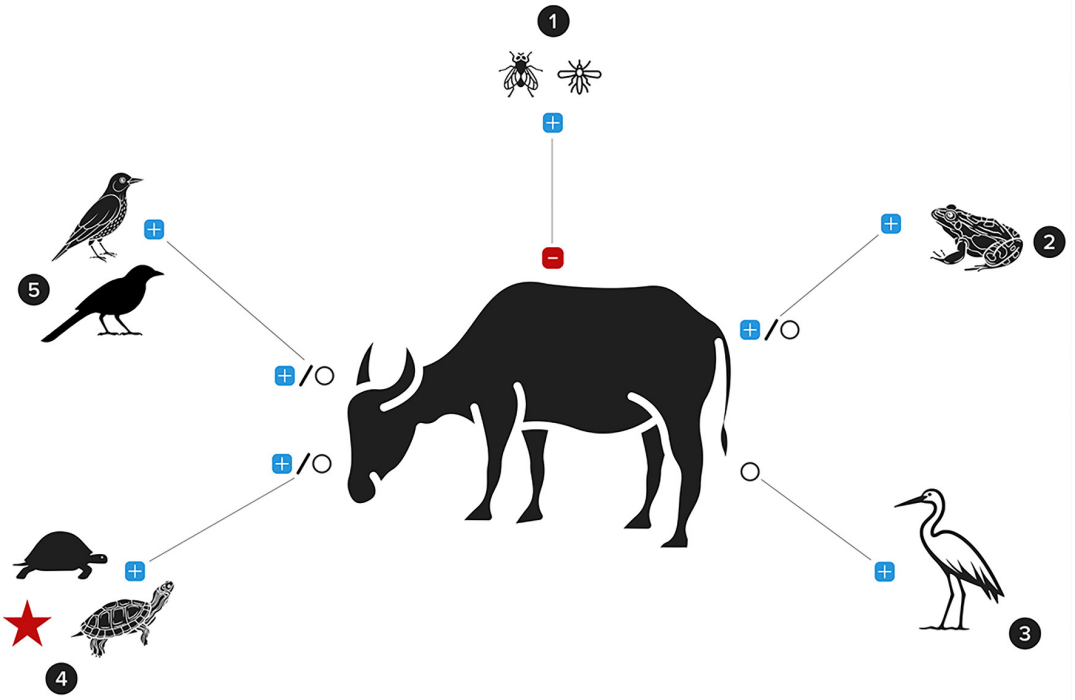

Figure 3. A summary infographic of the interaction between buffalo species and wildlife. Blue boxes with plus symbols (+) indicate positive interactions, the red box with the minus symbol (–) is a negative interaction, and the zero symbol (0) is for neutral interactions. The numbered circles indicate the types of interactions: (1) parasitic (Huang et al., 2007; Villanueva et al., 2018); (2) mutualistic (Zduniak et al., 2017); (3) commensal (Choudhury and Barker, 2014; Verma et al., 2021); (4) mutualistic (Kerley, 2021); (5) mutualistic (Wiegleb and Krawczynski, 2010; Mikula et al., 2018). The red star shows the new interaction between turtles and Domestic Wild Buffaloes (*Bubalus bubalis*) we discovered in Türkiye.

(Fritz, 2001; Vignoli et al., 2015; Erdélyi et al., 2021). Although there is substantial knowledge regarding the basking behaviours of *Mauremys* terrapins, the taxonomic separation of this genus is relatively recent (Feldman and Parham, 2004). As a result, the basking structures reported for the genus include tree trunks, branches extending over the water, banks, and stones (Hofstra, 2003; Rifai and Amr, 2004; Mantziou and Rifai, 2014). Consequently, the observations presented here are considered the first examples of DWB-turtle interactions for both the European Pond Turtle and Western Caspian Terrapin.

Future research on DWB-turtle interactions could explore environmental parameters that could give insight into why turtles choose DWBs as basking sites, and the advantage of this choice compared to other options. It would also be interesting to extend observations over other wetlands where aquatic turtles and DWBs coexist, in order to determine whether this mutual interaction is widespread.

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