More Fun Than Fun: What Do Dogs (and Other Animals) Do All Day and All Night?

13/10/2021

Free-ranging dogs in Gayeshpur, a township close to the IISER Kolkata campus. Photo: Sourabh Biswas, a PhD student researching stray-dog behaviour and ecology

RAGHAVENDRA GADAGKAR

This article is part of the 'More Fun Than Fun' column by Prof Raghavendra Gadagkar. He will explore interesting research papers or books and, while placing them in context, make them accessible to a wide readership.

- *The amount of time an animal spends performing different tasks is called its time-activity budget.*
- *Raghavendra Gadagkar recalls the time he spent figuring out the time-activity budget of wasps in Bangalore's Cubbon Park, and the research insights that simple exercise led to.*
- *More recently, two scientists who determined the time-activity budgets of free-ranging dogs in West Bengal made a surprising discovery as well.*

My inspiration for this essay comes from reading a paper entitled 'Time-activity budget of urban-adapted free-ranging dogs', by Arunita Banerjee and Anindita Bhadra, published in the journal *acta ethologica* on September 8. This study provides a rigorous quantitative answer to the question raised in the title of my essay, at least for stray dogs in India.

People often ask me why I like some papers more than others. One of my answers is that a paper should make me jealous that I did not write it. This feeling can only come if I could easily have conducted that study and written the paper, at least in principle. Arunita and Anindita's paper has the potential of making every citizen of India jealous because any one of us could have done their study and could have done it anytime in the last 100 years, if not earlier.

But there is also another reason why this paper moved me so much. It brought back fond memories of my own research in the late 1970s and early 1980s, when I was studying the Indian paper wasp *Ropalidia marginata* as a hobby. At that time, I was a doctoral student at the Microbiology and Cell Biology Laboratory at the Indian Institute of Science (IISc), Bangalore, studying the interaction between bacteria and their viruses. But my heart was split between the molecular biological research that I loved very much and the exciting goings-on at the Centre for Theoretical Studies (CTS) at IISc. In CTS, I often hung around the famous ecologist Madhav Gadgil and his students. Madhav Gadgil had established a field research station in the nearby Bandipur Tiger Reserve and National Park.

Chital and other animals in Bandipur

Gadgil's aim was to initiate long-term ecological studies at Bandipur. His student H.C. Sharatchandra camped full-time in the park, and Gadgil regularly visited from Bangalore. At the end of the first year of their study, they published an inspiring account entitled 'A year of Bandipur' in the *Journal of Bombay Natural History Society* in December 1975. They summarised their preliminary findings thus:

> "Bandipur is a dry deciduous forest dominated by *Anogeissus latifolia* and *Tectona grandis*. The study area of 23 sq km supported a population of 800 chital (*Axis axis*), 90 elephants (*Elephas maximus*), 20 sambar (*Cervus unicolor*), 40 wild dogs (*Cuon alpinus*), over 10 panthers (*Panthera pardus*) and 10 or fewer tigers (*Panthera tigris*) and a small number of gaur (*Bos gaurus*), barking deer (*Muntiacus muntjack*), wild pig (*Sus scrofa*), and sloth bear (*Melursus ursinus*)."

As a city-dweller, I found this kind of science mesmerising. But one of Sharatchandra's projects captivated me even more. He was especially watching chital, to understand how they spent their time. What could be a more common-sense approach to science, I thought to myself.

A few years later, Sharatchandra and Gadgil reported that they had observed randomly chosen chital and recorded their behaviours until they went out of sight. From 6,500 such observations during daylight hours, they determined how much time chital spent performing different tasks.

Such apportionment of time is called a time-activity budget or, simply, a time-budget. To make a time-budget, they first categorised chital activity into eight categories: locomotion, anti-predator behaviour, grooming, trophic behaviour, fighting, play, displays and sexual behaviour.

They found that chital, in general, spent 80-90% of their time in trophic behaviours, 4-8% in antipredator behaviours, less than 6% fighting, less than 5% in display, just about 1% or less in locomotion, a similar amount in grooming, about 2% in play and about 0.5% in sexual behaviour.

Next, they separately calculated time-budgets for juveniles, adult females, adult males in velvet and adult males with hard antlers – and found interesting differences between the different life stages. For example, males with hard antlers spent relatively less time on trophic behaviours and relatively more time in display, fighting and locomotion. Adult females spent relatively more time in anti-predatory behaviours, and the juveniles spent more time in play.

Clearly, chital in different life-stages apportioned their time to different behaviours in an adaptive manner. I looked for but found few such data for other animal species. The lack of data was surprising because it seemed so easy and so much fun to do this kind of research. I could not help feeling that knowing the time-budgets of different animals under different conditions could tell us so much about how and why animals do what they do.

I resolved that I would calculate the time-activity budgets for my wasps at the earliest opportunity.

Wasps in Cubbon Park

A typical nest of the Indian paper wasp Ropalidia marginata, photographed more recently on the IISc campus. Photo: Souvik Mandal

An opportunity presented itself when I found some naturally occurring nests of *R. marginata* right in the middle of Cubbon Park, in Bangalore. The park was a frequent haunt of mine both because it was close to Central College and because it then had an excellent public library. I spent many hours sitting in front of the wasp nests with a notebook and pencil (often surrounded by a bunch of curious children) and observed the insects.

As a first step, I made a list of all that the wasps did, in plain English, as a layman would. My list read as follows: sit with folded legs and lowered antennae; sit with raised antennae; sit with raised antennae and wings; groom oneself; walk; inspect the cells; feed the larvae; attack, peck or chase another wasp; absent from the nest; return with food; building material; water or nothing; and so on. My list grew to a little more than 100 items.

Such a list is called an ethogram and is the first step towards conducting an observational study of the behaviour of any animal species.

But I still lacked two crucial ingredients for my research. For one, I did not know how to mark the wasps for individual identification.

The Mahabaleshwar seminar

It was my great fortune that the world's most famous wasp researcher, Mary Jane West-Eberhard, came to India to participate in a seminar on '[Evolution of Social Behaviour]' that Madhav Gadgil had organised, in October 1979. Being one of the annual seminars on modern biology sponsored by the Tata Institute of Fundamental Research, Ahmednagar College and the University Grants Commission, it was held at the picturesque hill station of Mahabaleshwar, near Pune in Maharashtra.

A galaxy of the world's greatest experts on social behaviour, including John Maynard Smith, William G. Eberhard, John Hurrell Crook, Robert L. Trivers and John. F. Eisenberg participated in the seminar, apart from Mary Jane herself. We had the unique opportunity of taking long walks with these experts in the afternoons, which were deliberately free of formal lectures. Every one of these experts made an indelible impression on me, and I stayed in touch with them for a long time after that.

But Mary Jane West-Eberhard was very special. For one thing, she was a wasp expert (some of us call her the 'wasp queen'!). She is also one of the kindest and most altruistic scientists I have had the privilege of knowing. She came to Bangalore and stayed on for a few weeks and, among many other things, she taught me how to mark the wasps.

She also left behind her box of Testors enamel paints that she always carried with her when she travelled. She also left behind several thousand rupees that she had saved from her per-diem, as a start-up grant for my research on wasp behaviour. I set that aside, calling it the 'Mary Jane Fund', and it was more than sufficient to finance my low-cost research for some years. It even afforded me the luxury of travelling daily in an auto-rickshaw to Cubbon Park and back.

Making unbiased observations

The second missing ingredient was a knowledge of how to observe the wasps without introducing human bias. Subconscious human bias is not something that can be avoided merely with good intentions and willpower. I needed a better way, and I found it in the now-famous paper '*Observational Study of Behavior: Sampling Methods*' (1974) by Jeanne Altmann. Like thousands of other researchers (the paper has been cited over 17,384 times), I carefully studied Altmann's paper and standardised a package of unbiased sampling methods to observe the wasps.

My observation package included three methods of observation designed to reduce bias towards the more conspicuous animals and behaviours. One involves making a rapid scan of all the wasps on the nest and noting whatever they are doing at that instant, much like taking a still photograph. This is called an "instantaneous scan" or scan sampling. I made my random choices by drawing lots: I began with small pieces of cardboard with the wasps' names written on them in my left pocket, and moved them one by one to my right pocket, and started all over again.

The second method involved randomly choosing one wasp at a time for observation and observing only that wasp, no matter what it did. This method is called focal animal sampling.

In the third method, I chose a small set of very rare behaviours (which were not adequately sampled by the other two methods) and recorded every occurrence of each of those behaviours by any wasp in a predetermined period of time. We simply call this method 'all occurrences'.

Applying a combination of these sampling methods to observe uniquely marked wasps on two colonies in Cubbon Park, I fulfilled my dream of computing the time-activity budget of *R. marginata*. The result was most surprising. Most wasps spent about 95% of their waking hours in just six of the 100-odd behaviours I observed. And at first sight, these six – sit and groom, sit with raised antennae, sit with raised wings, walk, inspect cells and be absent from the nest – seemed to be rather inconsequential to the lives of the wasps. They were not quite in the same class as feeding, fighting and mating

But I said to myself: if I am not to be biased towards conspicuous behaviours during observation, why should I be biased towards seemingly important behaviours during interpretation? So I decided to see what sense I could make of the life of the wasps by studying the six behaviours in which the wasps found it worthwhile to spend 95% of their time.

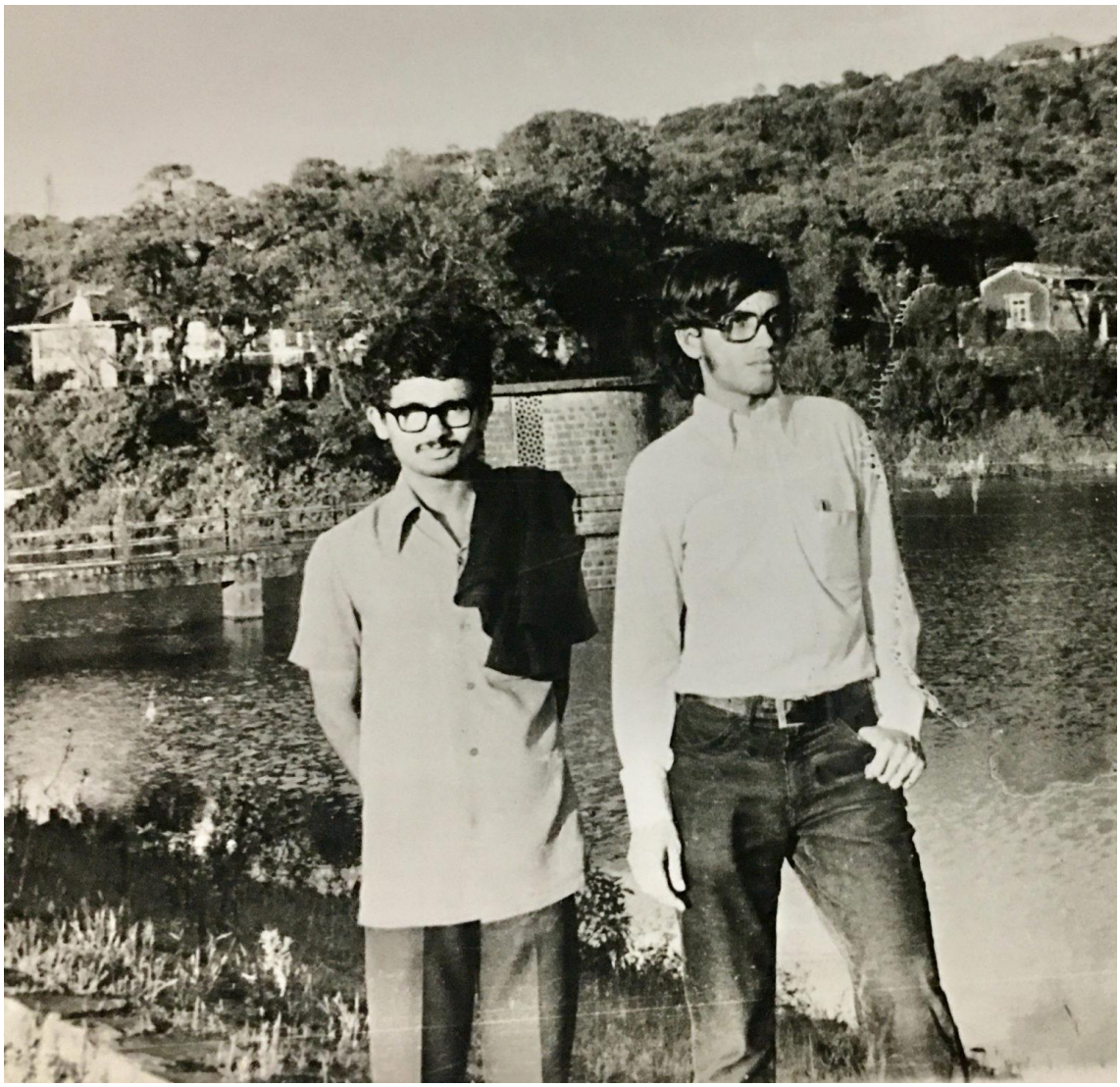
Indeed, there was a most interesting pattern. While nearly every wasp devoted about 95% of its time to these six behaviours, they varied enormously in the manner in which they distributed their time *between* the behaviours. Some wasps spent 50% or more of their time sitting and grooming themselves and 10% or less time away from the nest. Some others did the opposite, spending 70% or more of their time away from the nest and 10% or less sitting and grooming themselves. Yet others spent more time sitting with raised antennae than they did sitting with folded antennae and wings or being away from the nest.

Why do the wasps' time-budget activities vary so much? Was there a method in their madness – a hidden pattern in their behaviour that might tell us something profound about the organisation of their society?

Behavioural castes

Science is a collective activity, and I spent countless hours discussing these matters with my friend and colleague Niranjan V. Joshi. It always helps to discuss your science with someone who is not working in the same field.

When I joined IISc for my PhD, it was my great fortune that I was allotted a room in the hostel that had also been allotted to Joshi. We made great roommates. I told him all about my observations and experiments, my results and interests, especially during long walks back from the city after watching late-night movies.



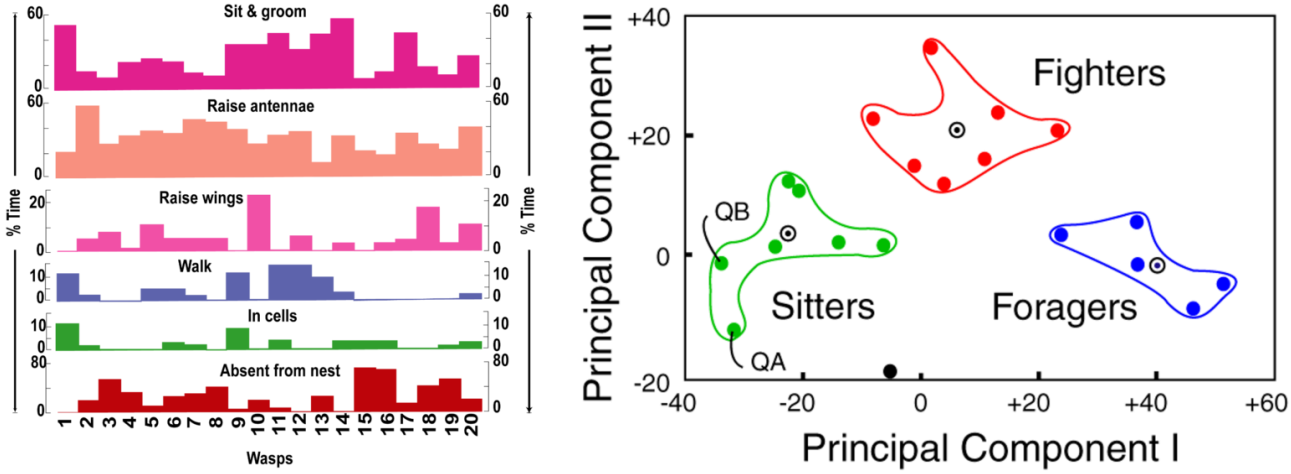
N.V. Joshi (left) and the author around the time of the research described here, on the sidelines of the Mahabaleshwar seminar on 'Evolution of Social Behaviour'. Photo: RG Lab collection

It turned out that quite fortuitously, Joshi was grappling with a similar problem in a totally different context. While pursuing his PhD on the molecular structure of polysaccharides, he was also helping another colleague, Sulochana Gadgil, make sense of the pattern of rainfall distribution over different parts of India. To do so, he was using a statistical technique called principal components analysis. It became obvious to us that we could use the same technique to make sense of the variation in the time-activity budgets of the wasps.

Well, it worked like a charm.

This technique takes information on the time spent by different wasps in the six behaviours as input and returns two new variables as output – such that most of the information (or variation) is contained in the two new variables. For all practical purposes, we could now focus just on the two variables, called the principal components. When we plotted the positions of the wasps on a graph, with principal component 1 on the X-axis and principal component 2 on the Y-axis, we had a eureka moment. The wasps arranged themselves in three distinct clusters.

Our data revealed that wasps in the first cluster spent most of their time sitting and grooming, so we called them ‘Sitters’. Wasps in the second cluster were very active in fighting with each other, so we called them ‘Fighters’. And wasps in the third cluster spent a lot of time away from the nest, so we called them ‘Foragers’.



Left: Time-activity budgets of 20 individually identified wasps from two colonies of the Indian paper wasp Ropalidia marginata, studied in Cubbon Park. Reproduced with permission from Gadagkar R., 1985. Proc. Indian Acad. Sci. (Anim. Sci.) 94 309–324. Right: The three behavioural castes, ‘Sitters’, ‘Fighters’ and ‘Foragers’, revealed by plotting them in the principal component space. Gadagkar, R. and Joshi, N.V., 1983. Animal Behaviour 31 26–31.

When workers in a colony specialise in different tasks, they are called castes. In advanced societies, such as those of ants, the different castes are also morphologically different. In our case, the Sitters, Fighters and Foragers were morphologically indistinguishable, so we called them *behavioural* castes. (Morphology refers to the forms and features of an individual body.)

The construction of time-activity budgets and the consequent discovery of behavioural castes in the Indian paper wasp was an early success that laid the foundation for nearly everything my students and I have discovered about this fascinating species in the nearly 40 years of subsequent research. During data analysis, I had deliberately not treated the queens of the wasp colonies any differently than I had treated the workers. So after the analysis, we could ask: where was the queen in this pattern? Was she a Sitter, a Fighter or a Forager?

Because queens in similar species were known to be aggressive individuals that suppressed their workers through physical intimidation, we naturally expected the queens of *R. marginata* to be Fighters. But we were most surprised to see that our queens belong to the Sitters. A counter-intuitive result like this is a powerful catalyst for rapid progress, as it served in our case.

Over the years, my students and I discovered that queens could afford to be meek and docile Sitters because they rub their non-volatile pheromones onto the nest’s surface to signal their presence to their workers. The workers regulate their own foraging and other activities through a process of decentralised self-organisation. Pre-designated potential queens periodically replace queens in a remarkably conflict-free process.

Our early knowledge of the time-activity budgets of the wasps continues to steer our research in newer and unexpected directions four decades on.

What do dogs do with their time?

Let us now return to Arunita Banerjee and Anindita Bhadra’s study of the time-budgets of dogs. Their study surpasses those of the chital and paper wasps I have just described on several counts.

When workers in a colony specialise in different tasks, they are called castes. In advanced societies, such as those of ants, the different castes are also morphologically different. In our case, the Sitters, Fighters and Foragers were morphologically indistinguishable, so we called them *behavioural* castes. (Morphology refers to the forms and features of an individual body.)

Arunitha Banerjee (left) and Anindita Bhadra displaying a passion for their study animals. Photos: Arunitha Banerjee and Anindita Bhadra, resp.

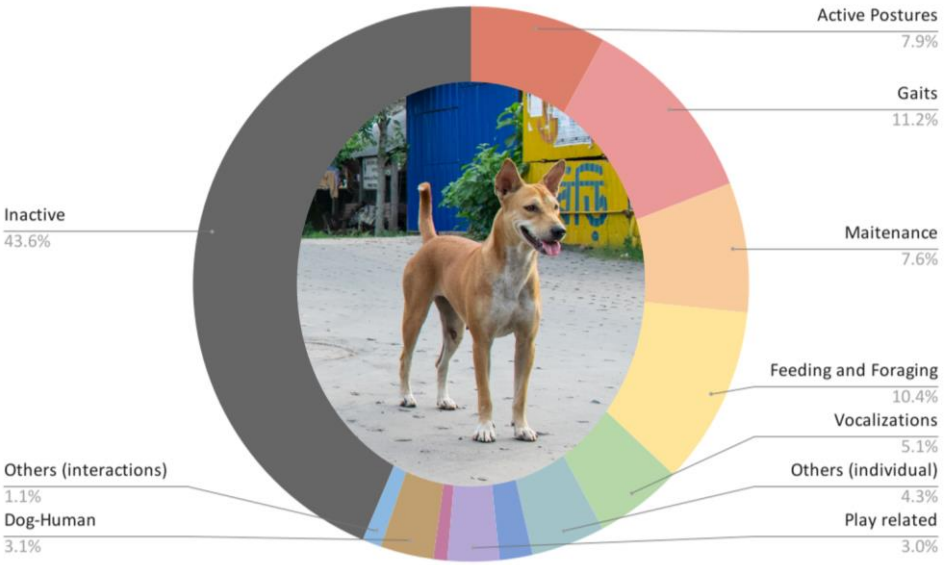
First, let us spare a thought for young Arunitha, who collected the data. The ethogram came from the combined observations of all the members of Anindita's 'Dog Lab' for *12 years*. Anindita tells me that their latest count for the total number of unique dog behaviours is 177 – and counting. But the time-activity budgets were made by Arunitha by the method of instantaneous scanning. Her data constitutes 5,669 sightings over one year.

To make these sightings, Arunitha walked day and night, in predetermined routes and at randomly chosen spots, in several suburban regions of West Bengal, including the campus of IISER Kolkata, Gayeshpur, Haringhata, Kanchrapara, Kalyani, Halisahar, Naihati, Barrackpore, Balindi, Jaguli and Mohanpur. Whenever she saw a dog, she noted, initially in her pocket notebook and later on her phone, the age, sex and behaviour of the dog as well as the date, time and location of the sighting.

Arunitha told me in an email:

> "On weekends, I would purchase a to and fro ticket from Kalyani station with the destination being Barrackpore, which was nine stations away. Train stations in the pre-pandemic times were centres of bustling human activity, with multiple eateries, rickshaw stands and major bus stands nearby. This ensured that there was no dearth of dogs in the area; in fact, many lived in the stations because it served as a good source for both food and shelter. So now I would board the train at Kalyani, and depending on the halts in the particular train's route, I would deboard randomly at one of these ten stations.
>
> Once I was done scanning the station premises and the adjoining areas for dogs, I would take the next train, in whichever direction it might be and deboard again at a different station."

With these sightings and applying clever statistical techniques that I will not go into, Arunitha and Anindita calculated the time-budgets of the Indian stray or free-ranging dog, or at least of those that live in West Bengal.



The dog's time-activity budget averaged over males and females, at different times of the day and different age classes. Plot: Arunitha Banerjee and Anindita Bhadra; inset photo: Sourabh Biswas

Notice that the most common behaviour is that of being inactive while those of showing various active postures and gaits, foraging and feeding, vocalisation and play occupy decreasing amounts of the dogs' time.

What I have presented here is only an average time budget that hides much interesting variation across the time of day and seasons of the year – not to mention the age, sex and the physical and social environment of the dogs. As it did for the wasps, the dog time-budget will raise many questions and is sure to guide Anindita Bhadra and her students on a path of discovery, to yield many surprising facts about these all too familiar animals.

One big surprise is already evident in their research paper. It is our common perception that dogs are primarily nocturnal. But their research has shown that stray dogs are just as active during the day as they are at night. The canines appear to be highly adaptive and manage to survive under most conditions created by humans. How did they become so adaptive? Is it a by-product of domestication, or could it be that the ability to adapt was a prerequisite for domestication?

Clearly, a scientific understanding of dogs will tell us much – not only about dogs and how we should adapt to them but also about evolution in general and domestication in particular. Being found everywhere and easy to observe and experiment with, dogs are well-suited for both basic research in ethology and behavioural ecology and to produce knowledge relevant to society, especially in the context of human-animal conflict. And yet, so few scientists in India study dogs. Part of the reason seems to be that we have a very narrow definition of what is respectable science and even of science itself.

But luckily, that is changing. It is a matter of great satisfaction that Anindita Bhadra has chosen to devote her career to the study of stray dogs in India. My optimism grows at the sight of the large number of bright and passionate young researchers being trained in her Dog Lab in IISER Kolkata. May their tribe flourish!

Raghavendra Gadagkar is a Department of Science and Technology (DST) Year of Science Chair Professor at the Centre for Ecological Sciences at the Indian Institute of Science, Bengaluru.

Gadagkar, R., 2021. More Fun Than Fun: What Do Dogs (and Other Animals) Do All Day and All Night? The Wire Science. URL https://science.thewire.in/the-sciences/what-do-dogs-and-other-animals-do-all-day-and-all-night/