

Historical sketch of Primates in Italian Zoological Gardens and their scientific relevance

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Abstract

In the present paper, we present an overview on primates in zoological gardens in post-unitarian Italy with a special emphasis on their scientific relevance. We carried out an analysis of the current collections and a comparison with historical data. Additionally, we provided an analysis of the scientific research concerning primates in Italian zoological gardens in the last 14 years. A significant difference between the frequency of the different research categories and the studied species was found. More than half of the publications concerned ethology and the majority of the species was studied in only a single publication while a lower number of species was the subject of a relatively high number of ethological publications such as *Lemur catta* and *Mandrillus sphinx*.

KEY WORDS: primates / zoological gardens / scientific research / historical overview

Quadro storico e rilevanza scientifica dei Primati nei giardini zoologici italiani

In questo articolo presentiamo una panoramica dei primati nei giardini zoologici dell'Italia post-unitaria con un' enfasi sul loro ruolo scientifico. Abbiamo svolto un' analisi delle collezioni attuali e un confronto con i dati storici. Inoltre, abbiamo svolto un' analisi della ricerca scientifica sui primati nei giardini zoologici italiani negli ultimi 14 anni. Una differenza significativa tra la frequenza delle diverse categorie di pubblicazioni scientifiche e le specie studiate è stata trovata. Oltre la metà delle pubblicazioni riguardava l' ambito etologico. La maggioranza delle specie è stata studiata in una singola pubblicazione mentre un ridotto numero di specie come *Lemur catta* e *Mandrillus sphinx* è stato oggetto di un numero relativamente alto di pubblicazioni.

PAROLE CHIAVE: primati / giardini zoologici / ricerca scientifica / panoramica storica

INTRODUCTION

Despite the historical traditions in the development of Natural History along the Italian Peninsula during Renaissance, literature concerning the keeping of wild animals, especially Primates, in menageries and zoological gardens has received relatively scarce attention, despite a recent increase of historical interest (Masseti & Veracini, 2010). The fact that Italy was one of the last European countries to have a long-lasting modern zoological garden (1911 in Rome) and that similar institutions were extremely rare until the economic boom of the 1960s exemplify the critical relationship between modern Italians and wildlife (Gippoliti, 2021a). Today there is still a lack of literature concerning the

activities and history of Italian zoological gardens. While zoologists have produced some publications on this topic (Finotello, 2004; Gippoliti, 2010), the majority of publications has been produced by local historians with little scientific background (Argnani and Silimbani, 2011; Robecchi, 2014). However, even if sketchy, the growing literature may provide crucial data to researchers interested in the development of zoo biology and zoo history in Italy. As an example of this kind of research, we highlight a recent paper on the history of polar bears in Italian zoos, a contribution to a finer knowledge of the species in confined habitats (Frascchetti, 2022).

MATERIALS AND METHODS

Literature sources provided most data on the history of primates in Italian zoos, and one paper provided clues of the relationship between zoos and the study of primate biology in Italy (Gippoliti, 2021b). Regarding the current situation, in order to provide a description of the current primate collections of Italian zoos, we accessed from the Zoo Information Management System data concerning the species kept and respective number of zoos which keep them on August 29th 2024 (<http://zims.species360.org/>). As a conspicuous number of Italian zoological gardens does not have a ZIMS subscription, data for those institutions was accessed from the public website Zootierliste (<https://www.zootierliste.de>) on August 29th 2024. We made a descriptive analysis concerning the representation of the different families and the number of zoos which keep the different species.

To investigate the current scientific role of the primate collections of licensed Italian zoological gardens, we performed a literature search on Google Scholar on 7th September 2024. We searched the name of each licensed zoological garden as of September 2023 (<https://www.mase.gov.it>) followed by the word “Primates”. Only papers on peer reviewed journals published from 2010 were considered. For each paper we reported the species involved (from herein studied species), which were mentioned either in the materials or in the supplementary materials of each paper we found with our literature search. Papers involving both Italian and foreign zoos were not considered when it was not possible to determine which were the species kept in Italian zoos. Similarly, papers involving the group of *Sapajus apella* belonging to the CNR were not included, despite the animals being located within the premises of the Bioparco in Rome. We then assigned each paper to an exclusive category based on the topic. We chose the categories described in Table I. We then carried out descriptive analyses on the studied species, and the aforementioned categories. We carried out a chi-squared test with a significance level of $p < 0.05$ in order to infer if there a significant difference between the research categories and the number of studied species and between the number of publications for each species in each category. For the second test we divided the species in four categories:

species studied in a single publication, in two to four publications, in five to nine publications, and in more than ten publications.

LIVING PRIMATES IN ITALY

Primates had a critical role in shaping our understanding of nature and later of evolutionary theories. Following the publication of Darwin's *On the Origin of Species*, a growing debate interested even Italy, where at the time Rome was still under the Pope's rule. In 1864 Filippo De Filippi held a famous conference in Turin titled *L'uomo e le scimmie* (On man and monkeys, 1864). At that time people could observe monkeys, gibbons, and young orangutans at the Royal Zoological Garden, which was open to visitors only when the King was not in Turin. In Florence, at the time capital of Italy, a conference by the Russian physiologist Aleksandr Herzen *Sulla parentela tra l'uomo e la scimmia* (on relationship between man and monkey) was held (1869) and produced a considerable debate on Darwinism principles applied to our own species.

King Vittorio Emanuele II encouraged the creation of a public Zoological Garden in Florence but, from the data available, no apes were kept there. Therefore, most Italians could only see living young apes occasionally in travelling menageries that were also the only source available to most anatomists and zoologists. In 1888 a young chimpanzee died in the Back Menagerie and provided unique material for the Turin Anatomists Carlo Giacomini and Giuseppe Sperino (Sperino, 1898). Apparently, there was little opportunity to describe the behaviour of monkeys and apes. Michele Lessona was the only zoologist to be familiar with orangutans living in Turin (Fig. 1) (Lessona, 1889). His ideas on how to keep this species in captivity (i.e. in a complex indoor environment; Gippoliti, 2000) and the need of conspecifics, the keepers and their families demonstrates a full acknowledgement of the elevated psychological needs of young orangutans. Little is known about eventual psychological-behavioural observations, but Paolo Lioy reported some observations by Lessona at his request on the use of the right or left hand by monkeys in the Turin Zoological Garden and a little chimpanzee in a travelling menagerie (Lioy, 1873).

Table I. Categories assigned to each paper and their definition.

Category	Definition
Ethology	Self-explanatory
Husbandry	dealt with how the animals are or have been kept and managed in a zoological garden
Microbiology	dealt with seroprevalence or molecular analyses of bacteria, viruses, and gut bacteria
Molecular biology	dealt with analyses on Primates DNA
Parasitology	dealt with parasite infections or their molecular analyses
Veterinary sciences	dealt with clinical cases, histological analyses, or treatment of infections



Figure 1. Monkey house of the Regio Giardino Zoologico di Torino at the end of the 19th century (Archivio Gippoliti).

Despite the lack of zoological gardens, primates were certainly held with a variable degree of success by private holders and in the gardens of some cities. The nobleman and surgeon Enrico Cartolari (1881-1969) held in his native Verona a small private menagerie that included not only a giraffe, but also at least one *Chlorocebus pygerythrus*, *Macaca rhesus* and *Eulemur macaco*. Today some data may be extracted from the records of the oldest museum collections. Among the most scientific-oriented holders, we would like to cite the naturalist Giuseppe Scarpa (1851-1937) in Treviso, founder of an important natural history collection now at the Seminario Arcivescovile in Treviso (Zanata *et al.*, 2011). According to a note published by Giovanni Battista Torossi, Scarpa kept in his home a long-lived howler monkey *Alouatta*, a breeding pair of marmosets *Callithrix*, a lion tamarin *Leontopithecus rosalia* (Linnaeus, 1766) and a night monkey *Aotus* sp. (Torossi, 1897). On 8th May 1907 he acquired a spider monkey *Ateles hybridus* (I. Geoffroy, 1829) who lived until 2nd May 1934 and whose skeleton and mounted skin are now preserved as almost all primates that died in his home (Zanata *et al.*, 2011). Other species he held include young chimpanzees and orangutans for short periods, and species of genera *Eulemur*, *Loris*, *Cercopithecus*. Regrettably, it seems that Scarpa wrote nothing about his activity as captive animal breeder, although he recorded a lot of details with the specimens of his museum. We were not able to document any scientific interest toward primate behaviour in the first 50 years of post-unification Italy.

The opening of a large zoological garden in Rome in 1911 for the International Exhibition celebrating the 50th anniversary of Italy's unification offered new research opportunities. Managed by the German zoologist Theodor Knottnerus-Meyer (1876-1936), the collection provided by Carl Hagenbeck included apes, monkeys and lemurs. Knottnerus-Meyer documented some observations about the pair of chimpanzees, specifically about the ventro-

ventral position assumed during mating (Knottnerus-Meyer, 1914). At the time no chimpanzee had ever been bred in zoos. In the same report the author also noted that a male *Eulemur macaco* born in Rome in 1911 was already sexually mature in 1913 but two years later his colour was black only on the head, tail and hands. He also reported that in June 1914 an infant of the rare *Macaca hecki* (Matschie, 1901) was born with his face and hands of a white-pinkish colour and these gained a black colour, like the one of his parents, when he was four months old. These detailed observations by Knottnerus-Meyer ceased with the War when he was forced to return to Germany. After 1920 he resumed the role of scientific director of the Giardino Zoologico and describe additional behavioural observations in a popular book that was widely known internationally (Knottnerus-Meyer, 1926). In this volume Knottnerus-Meyer described his observation on the macaque colonies which at the times were kept in the "Villaggio delle scimmie" (Figure 2). He argued that in primates the main drive behind grooming was the search for crystallised secretions, which the animals would later eat, and that primates who had constant access to a pool, as was the case in Rome, engaged less frequently in this behaviour. This theory was partly criticised by Ewing (1935) who argued that monkeys do not produce crystallised secretions due to sweating but during grooming they tend to eat hair covered with salty secretions.

In 1917 Gioacchino Leo Sera (Rome 1878-Florence 1960) improved Italian contribution to Primatology by creating in Pavia the first journal dedicated to Primates, the short-lived *Giornale per la Morfologia dell'Uomo e dei Primati*. Sera's research programme included an extensive study of most of the primatological collections found in the major Italian Zoological and Anthropological museums (mainly Genoa, but also Turin, Milan, Pisa, Florence, Pavia, and Rome; Sera, 1918). Furthermore, in one of his primatological papers (Sera, 1923) on the relationship between skeletal characters and locomotion in primates, he particularly acknowledged the help of Theodor Knottnerus-Meyer, «che gli facilitò le frequenti e lunghe visite al Giardino Zoologico di Roma, di cui tanto giovamento ha tratto questo lavoro» (Sera, 1923). Specifically, Sera cites his observations of two geladas *Theropithecus gelada*, in Rome reporting their scarce arboreal capabilities. Oscar de Beaux studied specimens he collected in the Hagenbeck Tierpark and later deposited to the Museo di Storia Naturale in Genoa. His main interest in primatology was the use of *os penis* as a taxonomic character, especially in the genus *Macaca* and in Hominidae (de Beaux, 1917a, 1917b, 1929). He also developed a small zoological garden in the park of Nervi but at the outbreak of war in 1940 the zoo was dismantled without any known scientific contribution to primatology (Gippoliti, 2006a).

In the subsequent years, the scientific contribution

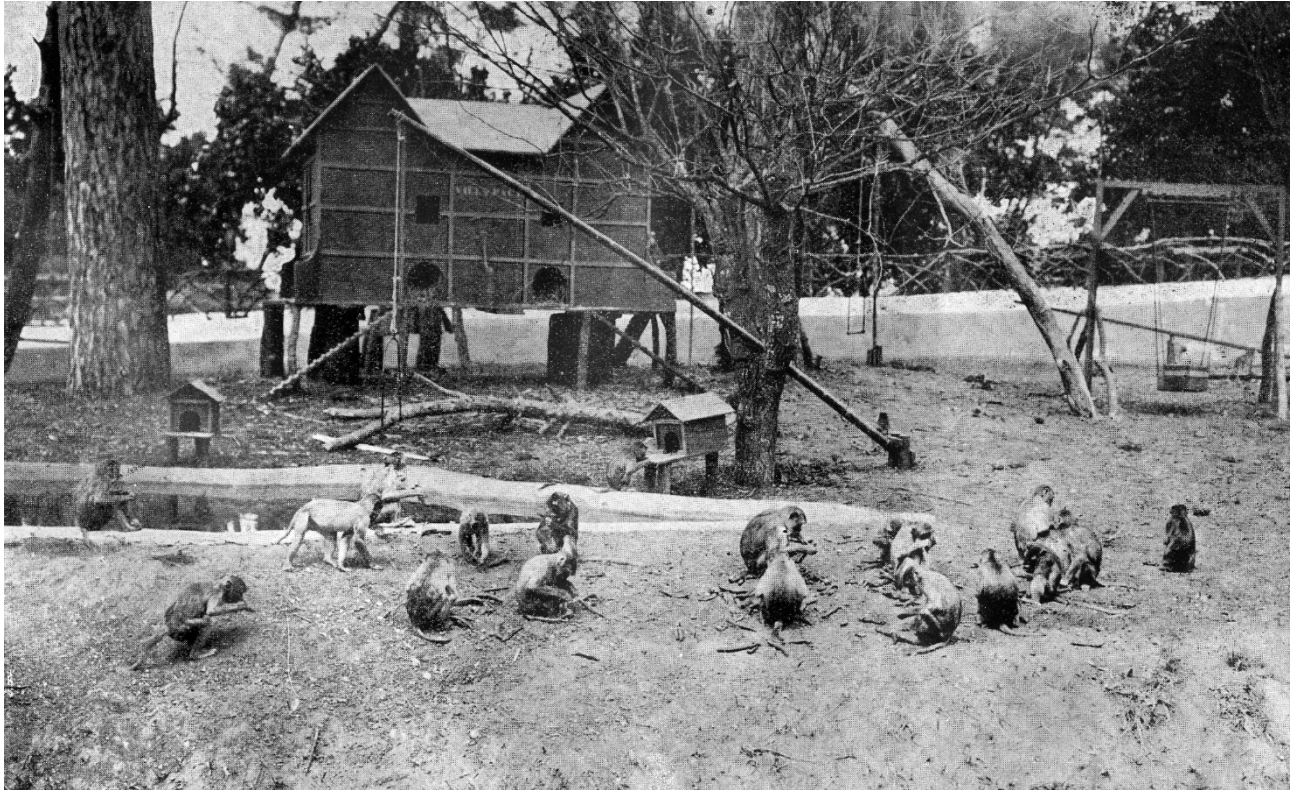


Figure 2. Macaques in the Villaggio delle scimmie at Giardino Zoologico di Roma in the 1920s (Knotterus-Meyer, 1925).

of Italian zoological gardens to primatology was quite scarce if non-existent. An inversion of this trend took place only after the end of WWII at the Giardino Zoologico di Roma. In particular, the appointment of the new veterinary Bertolino in 1952 (Gippoliti, 2010) led to an increase of veterinary publications concerning primates. Among his research we remember the description of parasitosis in geladas (Bertolino, 1957) and tuberculosis on a number primate species (Bertolino, 1958) for which a list of individuals was provided, albeit without a scientific name (Table II).

In the 1960s Brunetto Chiarelli from the University of Turin was the first Italian professor of Primatology. He established a Primatological Centre in the Giardino Zoologico di Torino (Torchio, 1963), which under Alulah Taibel's direction in the late 1950s had already published the scientific bulletin *Zoo-Bollettino dei Giardini Zoologici di Milano e Torino* (Gippoliti, 2019). Chiarelli's research involved mainly molecular biology as he published the description of the Chromosomes of the orangutang (*Pongo pygmaeus* at the time) using samples from two individuals (1.1) kept in the Giardino Zoologico di Roma (Chiarelli, 1961). It is now known that the male belonged to *Pongo abelii* and the female to *Pongo pygmaeus* (Gippoliti and D'Alessandro, 2013). Chiarelli also used samples from different Italian zoological gardens for three publications concerning the morphometric analysis

of primate chromosomes (Chiarelli 1962a, 1962b, 1963). A list of the animals studied by Chiarelli in these three publications is provided on Table III. This list has an important value as it provides a glimpse of the primate collections as it includes several species which are no longer kept in Italian zoological gardens or in captivity altogether. It is also important mentioning that for these publications Chiarelli also used samples from animals belonging to the Busacchi animal dealer company which used to dispatch animals to different Italian institutions. Among these we find, 1.1 *Pan troglodytes*, 1.0 *Papio hamadryas*, and 1.0 *Symphalangus syndactylus*.

The 1980s saw the development of behavioural research on primates in Italian zoological gardens. This was mainly possible thanks to the collaboration between the Institute of Comparative Psychology of the National Research Council (CNR) and the Giardino Zoologico di Roma which led to the development of two research projects. One involved the study of behaviour and cognitive development of a colony of *Sapajus apella* which lived in the Giardino Zoologico (Fig. 3) but was owned and managed by the CNR (Antinucci and Visalberghi, 1986). The other project involved the intensive study of a colony of Japanese macaques *Macaca fuscata* which was donated to the Giardino Zoologico in 1977 from Japanese authorities and which was kept in the newly refurbished Villaggio delle Scimmie. Research on this

Table II. List of all the primate species mentioned by Bertolino (1958). As only the common names were reported, we listed the Italian common name and inferred the most likely scientific name. The individuals read as males and females. For example 5.1 Amadriade means five males and one female.

Name reported	Likely scientific name	Individuals
Amadriade	<i>Papio hamadryas</i> (Linnaeus, 1758)	5.1
Babuino	<i>Papio cynocephalus</i> (Linnaeus, 1766)	0.2
Cappuccino a gola bianca	<i>Cebus capucinus</i> (Linnaeus, 1758)	1.1
Cebo dai cornetti	<i>Sapajus apella</i> (Linnaeus, 1758)	1.1
Cercopiteco a gola bianca	<i>Cercopithecus albogularis</i> (Sykes, 1831)	2.1
Cercopiteco a mani nere	<i>Chlorocebus pygerythrus</i> (F. Cuvier 1821)	4.0
Cercopiteco giallo-verde	<i>Chlorocebus sabaues</i> (Linnaeus, 1766)	1.2
Cercopiteco grigioverde	<i>Chlorocebus aethiops</i> (Linnaeus, 1758)	2.4
Cinopiteco	<i>Macaca nigra</i> (Desmarest, 1822)	0.1
Drillo	<i>Mandrillus leucophaeus</i> (F. Cuvier, 1807)	0.1
Gelada	<i>Theropithecus gelada</i> (Rüppell, 1835)	0.2
Gibbone	<i>Hylobates</i> sp.	1.1
Hulmann	<i>Semnopithecus</i> sp.	0.1
Macaco	<i>Macaca fascicularis</i> (Raffles, 1821)	1.1
Mandrillo	<i>Mandrillus sphinx</i> (Linnaeus, 1758)	0.1
Mangabè a gola bianca	<i>Cercocebus lunulatus</i> (Temminck, 1853)	1.0
Mangabè a testa rossa	<i>Cercocebus torquatus</i> (Kerr, 1792)	1.0
Mona	<i>Cercopithecus mona</i> (Schreber, 1774)	0.2
Rhesus	<i>Macaca mulatta</i> (Zimmermann, 1780)	1.0
Sileno	<i>Macaca silenus</i> (Linnaeus, 1758)	1.0

Table III. A list of all the species kept in Italian zoological gardens mentioned by Chiarelli (1962a, 1962b, 1963) with the respective number of individuals and the institution. The individuals read as males and females. For example in the case of *Macaca mulatta* 2.1 means two males and one female. We update the taxonomy when needed.

Species	Individuals	Italian zoological garden
<i>Cercocebus galeritus</i> (Peters, 1879)	2.0	Roma
<i>Cercocebus torquatus</i> (Kerr, 1792)	4.0	Roma
<i>Hylobates lar</i> (Linnaeus, 1771)	2.1	Napoli (1.0) Torino (1.1)
<i>Hylobates agilis</i> (F. Cuvier, 1821)	2.2	Napoli (1.0) Roma (2.1)
<i>Hylobates moloch</i> (Audebert, 1798)	1.0	Napoli
<i>Lophocebus albigena</i> (Gray, 1850)	1.0	Napoli
<i>Lophocebus aterrimus</i> (Oudemans, 1890)	1.2	Roma
<i>Macaca assamensis</i> (M'Clelland, 1839)	1.1	Torino
<i>Macaca fascicularis</i> (Raffles, 1821)	0.1	Roma
<i>Macaca fuscata</i> (Blyth, 1875)	0.1	Torino
<i>Macaca mulatta</i> (Zimmermann, 1780)	2.1	Roma (1.1) Torino (1.0)
<i>Macaca silenus</i> (Linnaeus, 1758)	1.1	Torino
<i>Macaca sylvanus</i> (Linnaeus, 1758)	1.0	Torino
<i>Mandrillus sphinx</i> (Linnaeus, 1758)	1.1	Roma
<i>Mandrillus leucophaeus</i> (F. Cuvier, 1807)	1.1	Roma (1.0) Torino (0.1)
<i>Pan troglodytes</i> (Blumenbach, 1775)	1.1	Roma (0.1) Torino (1.0)
<i>Papio cynocephalus</i> (Linnaeus, 1766)	2.0	Roma
<i>Papio hamadryas</i> (Linnaeus, 1758)	0.3	Torino
<i>Pongo abelii</i> (Lesson, 1827)	1.0	Roma
<i>Pongo pygmaeus</i> (Linnaeus, 1766)	0.1	Roma
<i>Theropithecus gelada</i> (Rüppell, 1835)	1.1	Roma

colony involving topics such as mother-infant relationship, allogrooming, aggression and competition, and demography was carried out in the subsequent decades and a review of over 20 years of research on this colony and its main findings is found in Majolo *et al.* (2005). Other taxa studied at the Giardino Zoologica di Roma were the western lowland gorilla *Gorilla gorilla gorilla* (Savage, 1847) particularly Romina the only gorilla to have been born in an Italian zoo (Visalberghi, 1984) and Javan macaques *Macaca fascicularis* (Troisi and Schino, 1987). In the same decade, behavioural research in other Italian zoological gardens was quite scarce with some studies carried out at the Giardino Zoologico di Torino on pig-tailed macaques *Macaca nemestrina* (Figure 4) (Giacoma, 1983; Giacoma and Messeri, 1992) before its closure in 1988 and at the Cavriglia Natural Park on its colony of *Macaca fuscata* (Camperio Ciani *et al.*, 1984; Lunardini, 1989; Corradino 1990). Additionally, the 1980s saw the foundation of the API-Associazione Primatologica Italiana (De Stefano, 1984-1985). During the 2000s, other Italian zoological gardens, namely Giardino Zoologico Città di Pistoia and Parco Natura Viva, started to publish primatological research. In the first zoological garden research focus mainly on *Lemur catta* thanks to a collaboration with the University of Pisa (Palagi *et al.*, 2002; 2005; Palagi, 2009), while in the other behavioural research has been carried out on larger number of species (Gippoliti, 2021b).

COLLECTIONS

The first comprehensive checklist of the primate species kept in Italian zoological gardens was produced at the end of the 1980s by Gandini and Rocca (1988). Table IV reports a copy of this checklist with updated taxonomy. At the time 35 species were kept in Italian zoological gardens with nearly 60% of them (20 species) belonging to the Cercopithecidae family while the remaining families were not represented by more than five species. Seven species were represented by only a single individual and over one third of the species (37%) was kept in a single institution. At the time, the most common species (i.e. the ones found in more than 10 zoological gardens) all belonged to the Cercopithecidae: *Chlorocebus aethiops*, *Macaca fascicularis*, *Macaca nemestrina*, and *Papio hamadryas*.

Italian zoological gardens keep 50 species of primates belonging to eight families (Table V). The two families represented by the highest number of species are Cercopithecidae and Cebidae, represented respectively by 16 and 15 species. The other taxa are represented by less than 10 species with Lemuridae being represented by eight species while all the other families are represented by less than five species. Most species are kept either in one institution (23 out of 50) or in less than five (20 out of 50). The most common Lemuridae species are the

ring-tailed lemur *Lemur catta* being kept in 17 institutions, followed by the two *Varecia* species *V. rubra* and *V. variegata* which are both kept in nine institutions. In the case of South-American primates the most common species belong to Cebidae, respectively *Saguinus oedipus*, *Sapajus apella* (both kept in eight zoological gardens), and *Callithrix jacchus* (six zoological gardens) while species belonging to Atelidae and Pitheciidae are not common. Despite being the family represented by the highest number of species, the majority of Cercopithecidae species are kept in less than five zoological gardens with only *Macaca fuscata* being kept in six institutions. In the case of Hominoidea, *Hylobates lar* (Hylobatidae) and *Pan paniscus* (Hominade) are both kept in six zoos each while the remaining species are kept in four institutions or less.



Figure 3. Two individuals of *Sapajus apella* from the colony studied by the CNR. The animals still live in the Bioparco di Roma and are visible to the public but are managed by the CNR (Photo S. Gippoliti)



Figure 4. *Macaca nemestrina* at the Giardino Zoologico di Torino in 1985 (Photo P. Dollinger).

CURRENT RESEARCH

We found 88 papers published between 2010 and 2024 and involving 36 species of primates kept in Italian zoos (Figure 5). The chi-squared test indicated a significant difference between the frequencies of the publications of each category and those of the studied species (chi-squared=11.51, d.o.f.=5; p-value=0.042). Ethological research was the focus of 55% of publications (48 out

of 88) (Figure 5). The second most-represented category was veterinary sciences with roughly 20% of publications, followed by microbiology and parasitology (respectively represented by eight and seven publications). Molecular biology and husbandry were the least common categories with respectively four and two publications each. An equal number of species (18) was studied in both ethological and veterinary publications. Respectively

Table IV. Checklist of the primates in Italian Zoological gardens, respective individuals and institutions from Gandini and Rocca (1988). The individuals read as total, males, females, and indeterminate. For example, in the case of *Chlorocebus aethiops* 43 (20.20.3) means 43 individuals in total of which 20 are males, 23 are females and three are of indeterminate sex.

Family	Species	Individuals	Institutions
Lemuridae	<i>Eulemur macaco</i> (Linnaeus 1766)	4 (2.2)	1
	<i>Lemur catta</i> (Linnaeus, 1758)	1 (1.0)	1
Atelidae	<i>Ateles paniscus</i> (Linnaeus, 1758)	4 (2.1.1)	1
Cebidae	<i>Cebus capucinus</i> (Linnaeus, 1758)	7 (5.2)	2
	<i>Saimiri</i> sp.	18 (8.9.1)	5
	<i>Sapajus apella</i> (Linnaeus, 1758)	9 (5.4)	2
Cercopithecidae	<i>Cercopithecus diana</i> (Linnaeus, 1758)	4 (3.1)	3
	<i>Cercopithecus mona</i> (Schreber, 1774)	7 (2.5)	4
	<i>Cercopithecus nictitans</i> (Linnaeus, 1766)	5 (4.1)	2
	<i>Cercopithecus petaurista</i> (Schreber, 1774)	1 (1.0)	1
	<i>Cercocebus lunulatus</i> (Temminck, 1853)	11 (4.7)	2
	<i>Chlorocebus aethiops</i> (Linnaeus, 1758)	43 (20.20.3)	12
	<i>Colobus guereza</i> (Rüppell, 1835)	1 (1.0)	1
	<i>Erythrocebus pata</i> (Schreber, 1775)	6 (1.5)	1
	<i>Macaca arctoides</i> (I. Geoffroy, 1831)	5 (4.1)	3
	<i>Macaca assamensis</i> (McClelland, 1839)	4 (2.2)	2
	<i>Macaca fascicularis</i> (Raffles, 1821)	80 (39.22.19)	10
	<i>Macaca fuscata</i> (Blyth, 1875)	77 (33.42.2)	2
	<i>Macaca nigra</i> (Desmarest, 1822)	1 (0.1)	1
	<i>Macaca mulatta</i> (Zimmermann, 1780)	54 (30.23.2)	9
	<i>Macaca nemestrina</i> (Linnaeus, 1766)	41 (22.19)	10
	<i>Macaca sylvanus</i> (Linnaeus, 1758)	9 (4.4.1)	2
<i>Mandrillus sphinx</i> (Linnaeus, 1758)	6 (2.4)	2	
<i>Papio anubis</i> (Lesson, 1827)	18 (9.9)	6	
<i>Papio cynocephalus</i> (Linnaeus, 1766)	274 (5.4.265)	5	
<i>Papio hamadryas</i> (Linnaeus, 1758)	60 (25.28.7)	12	
Hylobatidae	<i>Hylobates lar</i> (Linnaeus, 1771)	9 (4.5)	4
	<i>Hylobates muelleri</i> (Martin, 1841)	2 (1.1)	1
	<i>Hylobates pileatus</i> (Gray, 1861)	1 (0.1)	1
	<i>Nomascus concolor</i> (Harlan, 1826)	2 (1.1)	2
Hominidae	<i>Gorilla gorilla</i> (Savage, 1847)	2 (1.1)	1
	<i>Pan paniscus</i> (Schwartz, 1929)	1 (1.0)	1
	<i>Pan troglodytes</i> (Blumenbach, 1775)	30 (13.17)	7
	<i>Pongo abelii</i> (Lesson, 1827)	1 (1.0)	1
	<i>Pongo</i> sp.	2 (0.2)	1

Table V. Species of primates kept in Italian Zoological gardens, the number of institutions in which they are kept, and the number of individuals reported on ZIMS. The individuals read as total, males, females, and indeterminate. For example, in the case of *Saguinus oedipus* 29 (11.12.6) means 29 individuals in total of which 11 are males, 12 are females and six are of indeterminate sex. For species which are kept only in institutions without ZIMS, n.a. was listed as the number of individuals.

Family	Scientific Name	Institutions	Individuals (ZIMS)	
Lemuridae	<i>Eulemur albifrons</i> (É. Geoffroy, 1796)	1	n.a.	
	<i>Eulemur coronatus</i> (Gray, 1842)	2	4 (2.2)	
	<i>Eulemur macaco</i> (Linnaeus 1766)	4	10 (7.3)	
	<i>Eulemur mongoz</i> (Linnaeus, 1766)	1	1 (1.0)	
	<i>Eulemur rubriventer</i> (I. Geoffroy, 1850)	2	n.a.	
	<i>Lemur catta</i> (Linnaeus, 1758)	17	87 (44.43)	
	<i>Varecia rubra</i> (É. Geoffroy, 1812)	9	6 (2.4)	
	<i>Varecia variegata</i> (Kerr, 1792)	9	15 (4.11)	
	Cheirogaleidae	<i>Microcebus murinus</i> (J. F. Miller, 1777)	1	5 (5.0)
Atelidae	<i>Alouatta caraya</i> (Humboldt, 1812)	1	2 (1.1)	
	<i>Ateles fusciceps</i> (Gray, 1865)	1	2 (2.0)	
	<i>Ateles paniscus</i> (Linnaeus, 1758)	1	n.a.	
Cebidae	<i>Callimico goeldii</i> (Thomas, 1904)	1	2 (1.1)	
	<i>Callithrix geoffroyi</i> (Humboldt, 1812)	2	5 (0.5)	
	<i>Callithrix jacchus</i> (Linnaeus, 1758)	6	3 (2.1)	
	<i>Cebuella pygmaea</i> (Spix, 1823)	2	1 (1.0)	
	<i>Leontopithecus chrysomelas</i> (Kuhl, 1820)	2	5 (2.3)	
	<i>Leontopithecus rosalia</i> (Linnaeus, 1766)	1	2 (2.0)	
	<i>Saguinus imperator</i> (Goeldi, 1907)	3	10 (8.1.1)	
	<i>Saguinus labiatus</i> (É. Geoffroy, 1812)	2	2 (2.0)	
	<i>Saguinus midas</i> (Linnaeus, 1758)	1	1 (0.1)	
	<i>Saguinus oedipus</i> (Linnaeus, 1758)	8	29 (11.12.6)	
	<i>Saimiri boliviensis</i> (I. Geoffroy and Blainville, 1834)	3	16 (8.8)	
	<i>Saimiri sciureus</i> (Linnaeus, 1758)	3	6 (2.4)	
	<i>Sapajus apella</i> (Linnaeus, 1758)	8	12 (5.7)	
	<i>Sapajus libidinosus</i> (Spix, 1823)	1	3 (1.2)	
	<i>Sapajus nigritus</i> (Goldfuss, 1809)	1	1 (1.0)	
Pitheciidae	<i>Pithecia pithecia</i> (Linnaeus, 1766)	2	11 (4.7)	
Cercopitheciidae	<i>Allochrocebus lhoesti</i> (P. Sclater, 1898)	1	2 (1.1)	
	<i>Cercocebus lunulatus</i> (Temminck, 1853)	1	5 (1.4)	
	<i>Cercopithecus cephus</i> (Linnaeus, 1758)	1	n.a.	
	<i>Cercopithecus mona</i> (Schreber, 1774)	1	3 (1.2)	
	<i>Cercopithecus neglectus</i> (Schlegel, 1876)	1	3 (2.1)	
	<i>Chlorocebus aethiops</i> (Linnaeus, 1758)	4	4 (2.2)	
	<i>Colobus guereza</i> (Rüppell, 1835)	3	5 (2.3)	
	<i>Macaca fascicularis</i> (Raffles, 1821)	1	n.a.	
	<i>Macaca fuscata</i> (Blyth, 1875)	6	66 (28.38)	
	<i>Macaca mulatta</i> (Zimmermann, 1780)	4	n.a.	
	<i>Macaca nemestrina</i> (Linnaeus, 1766)	2	2 (1.1)	
	<i>Macaca sylvanus</i> (Linnaeus, 1758)	4	14 (6.8)	
	<i>Mandrillus sphinx</i> (Linnaeus, 1758)	2	8 (2.6)	
	<i>Papio hamadryas</i> (Linnaeus, 1758)	3	n.a.	
	<i>Semnopithecus entellus</i> (Dufresne, 1797)	1	2 (1.1)	
	<i>Theropithecus gelada</i> (Rüppell, 1835)	1	4 (4.0)	
	Hylobatidae	<i>Hylobates lar</i> (Linnaeus, 1771)	6	14 (6.8)
		<i>Nomascus concolor</i> (Harlan, 1826)	1	2 (1.1)
		<i>Nomascus gabriellae</i> (Thomas, 1909)	2	8 (4.3.1)
<i>Symphalangus syndactylus</i> (Gloger, 1841).		4	12 (7.5)	
Hominidae	<i>Pan troglodytes</i> (Blumenbach, 1775)	6	14 (5.9)	
	<i>Gorilla gorilla</i> (Savage, 1847)	1	n.a.	

16 and 13 species were studied in microbiological and parasitological publications. Only five and two species were respectively involved in publications concerning husbandry and molecular biology.

Roughly 50% of the species have been studied in only one publication while around 42% have been studied in two to nine publications (Figure 6). Only four species have been studied in more than 10 publications: *Lemur catta* (26 publications), *Mandrillus sphinx* (18 publications), *Macaca fuscata* (13 publications), and *Pan troglodytes* (11 publications). When the species are broken down by the different research categories (Figure 6), the chi-squared test indicated a significant difference between the frequencies of the species studied in the different research categories (chi-squared=26.41, d.o.f.=15, p-value=0.033). In the case of ethological, parasitological, and veterinary research the majority of species was the subject of a single publication and a progressively smaller number of species was the subject of more publications. In the case of ethological research, two species *Mandrillus sphinx* and *Lemur catta* were studied in more than ten publications while *Macaca sylvanus* and *Pan troglodytes* were the only two species studied in five to nine publications. In the case of veterinary research *Lemur catta* and *Papio hamadryas* are the only two species which have been studied in more than four publications while in parasitology no species has been studied in more than four papers. Conversely, in the case of microbiology only 25% of the species have been studied in a single paper while the rest has been studied in two to four publications. In the case of molecular biology one species was studied in one publication and the other in three while in the case of husbandry all the species were the subject of one publication.

DISCUSSION

Primate families such as Lemuridae, Cebidae, and Cercopithecidae are represented in Italian zoological by a low number of species (i.e. one to three) which are rather common in the different institutions and a higher number of species which are present in a low number of institutions, a trend which is common with other mammalian Orders in Italian zoological gardens (Fraschetti and Gippoliti, 2022). Among the species belonging to the latter category, it is worth mentioning the threatened *Cercocebus lunulatus* a species which has been historically bred at the Giardino Zoologico di Roma (now Bioparco) (Figure 7) (D'Alessandro and Gippoliti, 1992; Gippoliti 2010) as part of a European captive breeding programme (EEP) through which its population in Europe has progressively increased (Jara *et al.*, 2016; Fraschetti and Gippoliti, 2024). Since the late 1980s primate collections in Italian zoological gardens have changed with an increase in the number of species, genus, and families kept. In particular, in the 1980s Lemuridae were not only

represented by two species but they were scarcely represented in the collections. Today they are represented by a higher number of species and some of them (i.e. *Lemur catta*) have become the most popular primate species in Italian zoos. Similarly, at the end of the 1980s, species belonging to Callitrichinae were not kept in any Italian facility while now they are represented by ten species with some of them such as *Saguinus oedipus* and *Callithrix jacchus* being quite widespread. Nonetheless, other South American taxa such as Atelidae and Pitheciidae are still

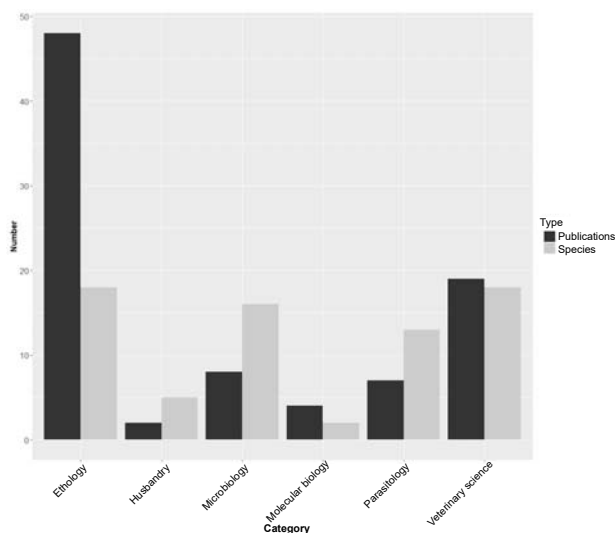


Figure 5. Breakdown of the publications concerning primates in Italian zoological gardens according to studied species and type of research.

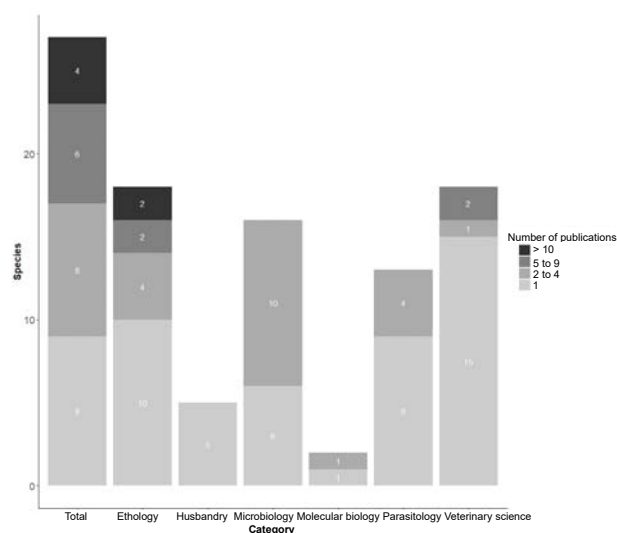


Figure 6. Breakdown of the species according to the number of publications which involved them. The breakdown was done for the cumulative sample and for all the different research categories. The number of publications which involved each species was colour coded according to the following intervals: one, two to four, five to nine, 10 or more.

quite rare in Italian zoos. Cercopithecidae while still being the family represented by the highest number of species, has seen a decrease from 20 to 16. During the 1980s, the most popular species in Italian zoological gardens all belonged to this taxon: *Chlorocebus aethiops*, *Macaca fascicularis*, *Macaca mulatta*, *Macaca nemestrina*, and *Papio hamadryas*. These species are now kept in far less institutions than at the time. While *Macaca* is still the most represented genus, with an increase of zoos keeping *M. fuscata* and *M. sylvanus*, some species such as *M. arctoides*, *M. assamensis*, and *M. nigra* have disappeared over the course of time as well as *M. leonina* (Bylth, 1863), once considered a subspecies of *M. nemestrina*, which was kept in the Giardino Zoologico di Roma (Gippoliti, 2001). In the case of Hylobatidae, *Symphalangus syndactylus* which was absent in the 1980s has become quite popular while in the case of Hominoidea, *Pongo*, a genus whose reproductions had been historically successful in Rome (Figure 8) (Gippoliti, 2000; Gippoliti and D'Alessandro, 2013), the genus has disappeared from Italian collections.

In the past 14 years primates in Italian zoological gardens have still been the subject of several scientific publications. In a similar fashion to the species held, only a minority of species has been the subject of a relatively high number of scientific publications. A significant difference between the frequencies of the research categories and the studied species was found. Continuing with the trend started in the previous decades, ethology was still the most important field of research with more than half of the publications dealing with this topic. The most studied species were *Lemur catta*, and *Mandrillus sphinx*. In the case of the first species, the collaboration started in the early 2000s between the University of Pisa and the Giardino Zoologico di Pistoia (Gippoliti, 2021b) has produced further research on the species (Palagi and Norscia, 2015; Palagi *et al.*, 2017; Zonato *et al.*, 2023) and other studies have been carried out in other zoological gardens such as Parco Natura Viva (Santacà *et al.*, 2017; Speizio *et al.*, 2017) and Roma (Schino and Alessandrini, 2018). *Mandrillus sphinx* is present in only two institutions but has been the subject of a number of studies carried out at Bioparco di Roma (Schino and Pellegrini, 2011; Schino and Marini, 2014; Schino and Sciarretta, 2016; Schino and Lasio, 2019; Schino and Scerbo, 2020). On the other hand, *Macaca fuscata*, whose colony in Roma had been the subject of a number of ethological studies in the past decades (Majolo *et al.*, 2005) was the subject of only three studies in the last 14 years (Schino and Alessandrini, 2015; Tiddi *et al.*, 2017; Balasubramaniam *et al.*, 2018) while some studies have been carried out on the *Macaca sylvanus* colony at Parco Natura Viva (Sandri *et al.*, 2017; Regaiolli *et al.*, 2018; Baldachini *et al.*, 2021). With the increase of Callitrichidae in Italian zoological gardens, species belonging to this taxon were the subject of some ethological studies such as *Saguinus oedipus*

(Fontani *et al.*, 2014; Schino *et al.*, 2023), *Saguinus imperator* (Speizio *et al.*, 2022) and *Callithrix jacchus* (Norscia and Palagi, 2011). While *Pan troglodytes* is a relatively popular species in Italian zoological gardens and chimpanzees in zoos have been extensively studied (Bloomsmith and Else, 2005), only three publications involving research on this species in Italian zoological gardens, always at Parco Natura Viva (Figure 9), have been published (Huffman *et al.*, 2011; Forrester *et al.*, 2012; Speizio *et al.*, 2021). Behavioural data have also



Figure 7. *Cercopithecus lunulatus* at Bioparco di Roma in 2012 (Photo by S. Gippoliti).



Figure 8. Orangutangs Sahib and Sahiba at Giardino Zoologico di Roma in 1928 (Archivio Gippoliti).



Figure 9. Chimpanzees at Parco Natura Viva (Photo by S. Gippoliti).

been used for comparative ethological studies involving species belonging to same family such as Callitrichidae (Regaiolli *et al.*, 2020), to more primate families (Fornalé *et al.*, 2012) or even comparing the behaviour of primates with that of Chiroptera (Carter *et al.*, 2019).

Research on veterinary sciences has concerned mainly clinical cases in a single facility involving species such as *Lemur catta* (Poglayan *et al.*, 2016; Rocchignani *et al.*, 2022) or *Symphalangus syndactylus* (Piga *et al.*, 2016). The colony of *Papio hamadrias* kept at Zoosafari Fasanolandia has provided the basis for a number of studies (Cutroneo *et al.*, 2015; Lacitignola *et al.*, 2022; Scardia *et al.*, 2023; Sgroi *et al.*, 2023). The description and treatment of outbreaks involving different species have been the subject of such as *Encephalomyocarditis* at Parco Natura Viva (Canelli *et al.*, 2010), and *Giardia duodenalis* at Parco Faunistico le Maitine (Capasso *et al.*, 2022) while some collections have provided their data for pooled research involving the levels of Vitamin D in *Pan troglodytes* in European zoological gardens (Moittié *et al.*, 2022) or ophthalmic examination in *Lemur catta* in Italian zoos (Rawicka *et al.*, 2023). A main trend for parasitological research could not be identified as it has either focused on molecular studies on parasites living in several species kept in Italian zoological gardens (Di Filippo *et al.*, 2020), on the description of parasites

assemblages (Berrilli *et al.*, 2011; Fagiolini *et al.*, 2010; Rondón *et al.*, 2024), or on clinical cases (Dini, 2023). In the case of microbiological research, it is worth mentioning that samples from *Saguins imperator* and *Saguinus oedipus* kept at Parco Natura Viva have been the basis for the description of four new species of the genus *Bifidobacterium* (Michelini *et al.*, 2016; Modesto *et al.*, 2018). Research on molecular biology has focused exclusively on samples from primates kept at the Bioparco di Sicilia such as the study of the chromosomes of *Cercopithecus petaurista* (Schreber, 1774) (Lo Bianco *et al.*, 2017; Tolomeo *et al.*, 2020; Milioto *et al.*, 2023) and the identification of the subspecies of *Pan troglodytes* through DNA analysis (Giangreco *et al.*, 2018). This last work is reminiscent of previous research which identified through DNA analysis an individual belonging to *Pan troglodytes vellerosus* (Gray, 1862) which was kept at the Giardino Zoologico di Roma (Gippoliti, 2007). Publications on husbandry, i.e. how captive primates are (or have been) managed in zoological gardens, has been rather neglected in Italian zoological gardens with only two publications in the last 14 years (Gippoliti and D'Alessandro, 2013; Gippoliti *et al.*, 2020). While the husbandry of primates in Italian zoological gardens has been somewhat historically neglected, a wealth of literature on the topic was produced in the past decades

(Gippoliti, 2006) also thanks to the *International Zoo Yearbook*, which ceased its publication in 2020.

In conclusion, despite the focus on animal behaviour, research on primates in Italian zoological gardens has been quite diverse, encompassing to a lesser extent stu-

dies on veterinary science, parasitology, and microbiology with some species remaining understudied. While animal husbandry remains understudied, an increase of publications on this topic would be beneficial in order to contribute to the welfare of these species in captivity.

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