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Il “Bollettino del Museo Civico di Storia Naturale di Verona” è la rivista del Museo, nata nel 1948 come “Memorie del Museo Civico di Storia Naturale di Verona” e divenuta nel 1974 “Bollettino”. Dal 2000 esce annualmente in due distinte sezioni: 1. Botanica e Zoologia; 2. Geologia, Paleontologia e Preistoria, e pubblica sia estesi contributi sia brevi note riguardanti gli aspetti naturalistici di tali discipline.
The “Bollettino del Museo Civico di Storia Naturale di Verona” is the Museum’s journal. Founded in 1948 as “Memorie del Museo Civico di Storia Naturale”, it became “Bollettino” in 1974. Since 2000 it is issued annually in two distinct parts: 1. Botany and Zoology; 2. Geology, Paleontology and Prehistory; both extended contributions and brief notes regarding the naturalistic aspects of these disciplines are published.

In copertina: *Mene rhombea* (Volta) Perciformes Menidae. Uno degli ittioliti più facilmente reperibili nei calcari eocenici della Pesciara (Bolca, Val d’Alpone, Monti Lessini orientali). Ciottolo inciso con raffigurazione di stambecco rinvenuto nel sito del Paleolitico superiore di Riparo Tagliente (Verona), conservato presso il Museo Civico di Storia Naturale di Verona.
Mene rhombea *(Volta) Perciformes Menidae. One of the most easily found Ichthyolites in the Eocene Limestones of the Pesciara locality (Bolca, Alpone Valley, eastern Lessini hills). Engraved pebble with ibex found in the Upper Palaeolithic site of Riparo Tagliente near Verona (Northern Italy), exposed at the Museo Civico di Storia Naturale di Verona.*

Grafica copertina: Damir Jellici

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BOLLETTINO
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MUSEO CIVICO DI STORIA NATURALE DI VERONA

Il ritrovamento di *Lactuca plumieri* (L.) Gren. & Godr. nelle Alpi Marittime (Liguria), prima osservazione in Italia

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Abstract

In this paper the first finding in Italy of the species Lactuca plumieri *(L.) Gren. & Godr. is presented. The finding occurred during the botanical explorations of the Museum of Natural History of Verona that took place in 1993, in Maritime Alps, Liguria.*

Key words: *New record,* Lactuca plumieri*, Colla di Langan, Colla Melosa, Liguria.*

Riassunto

In questo articolo presentiamo il primo ritrovamento della specie *Lactuca plumieri* (L.) Gren. & Godr. in Italia, avvenuto nel corso delle esplorazioni botaniche del Museo Civico di Storia Naturale di Verona, che nel 1993 si sono svolte nelle Alpi Marittime, in Liguria.

Parole chiave: Nuova segnalazione, *Lactuca plumieri*, Colla di Langan, Colla Melosa, Liguria.

Introduzione

Lactuca plumieri (L.) Gren. & Godr. è un'Asteracea distribuita nei Pirenei, Vosgi, Giura, Massiccio centrale, Cevenne, Alpi, Balcani, dal piano montano a quello subalpino (Pignatti *et al.*, 2018; Aeschimann *et al.*, 2004) (Figura 1). Nella flora alpina di Aeschimann non viene riportata nella penisola italiana, così come non è indicata nelle successive checklist italiane (Conti *et al.*, 2005, Bartolucci *et al.*, 2018).

In Italia viene citata per la prima volta da Pignatti *et al.* (2018) proprio su nostra segnalazione. Nel giugno del 1993, infatti, la Sezione di Botanica del Museo Civico di Storia Naturale di Verona ha organizzato una campagna di ricerca floristica nell'area che comprendeva Colla Melosa e Colla di Langan nelle Alpi Marittime (Liguria), nell'intento di raccogliere campioni d'erbario che sarebbero andati ad arricchire le già cospicue collezioni botaniche del museo.

Per vari motivi alcuni campioni raccolti nelle citate aree non ebbero allora classificazione e solo recentemente nel corso di una verifica fu notata tra le essenze erbacee la presenza di *Lactuca plumieri* (L.) Gren. & Godr., specie nuova per la flora italiana.

Si tratta di un'Asteracea perenne, alta 40-120 cm, mesofila, emicriptofita scaposa (H scap), che fiorisce in luglio-agosto; l'impollinazione è entomofila e la disseminazione anemocora.

È una pianta con fusto eretto, glabro, costoloso e cavo, ramificato all'estremità. Le foglie sono glabre e morfologicamente diverse tra inferiori e superiori, molli, abbraccianti il fusto alla base, leggermente glauche nella pagina inferiore. Le foglie superiori sono aguzze, talvolta semplicemente lobate o intere, le mediane profondamente incise, le inferiori assai ampie.

I capolini hanno caratteristici fiori bleu o violacei riuniti in corimbi, involucri glabri, brattee lanceolate o lineari-lanceolate, scariose, ligule bluastre. Gli acheni sono grigiastri, ellittici, compressi, acuminati e muniti di un ciuffetto bianco apicale.

Materiali e metodi

Nell'estate del 1993 è stata condotta una campagna di erborizzazione nelle Alpi Marittime (Liguria) da parte della Sezione di Botanica del Museo Civico di Storia Naturale di Verona. I reperti raccolti, dopo essere stati pressati ed essiccati, sono stati preparati per l'inserimento nell'erbario del

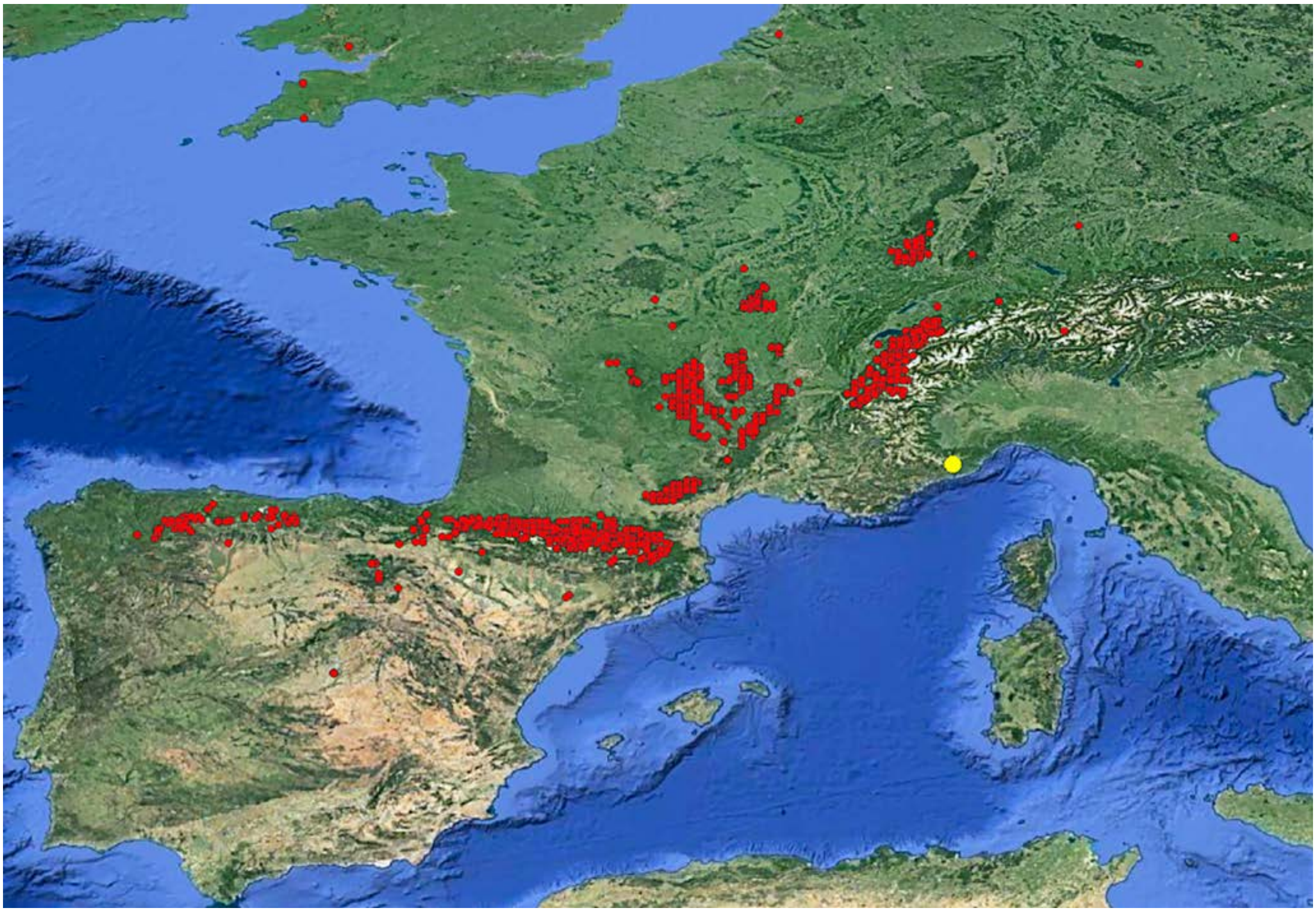


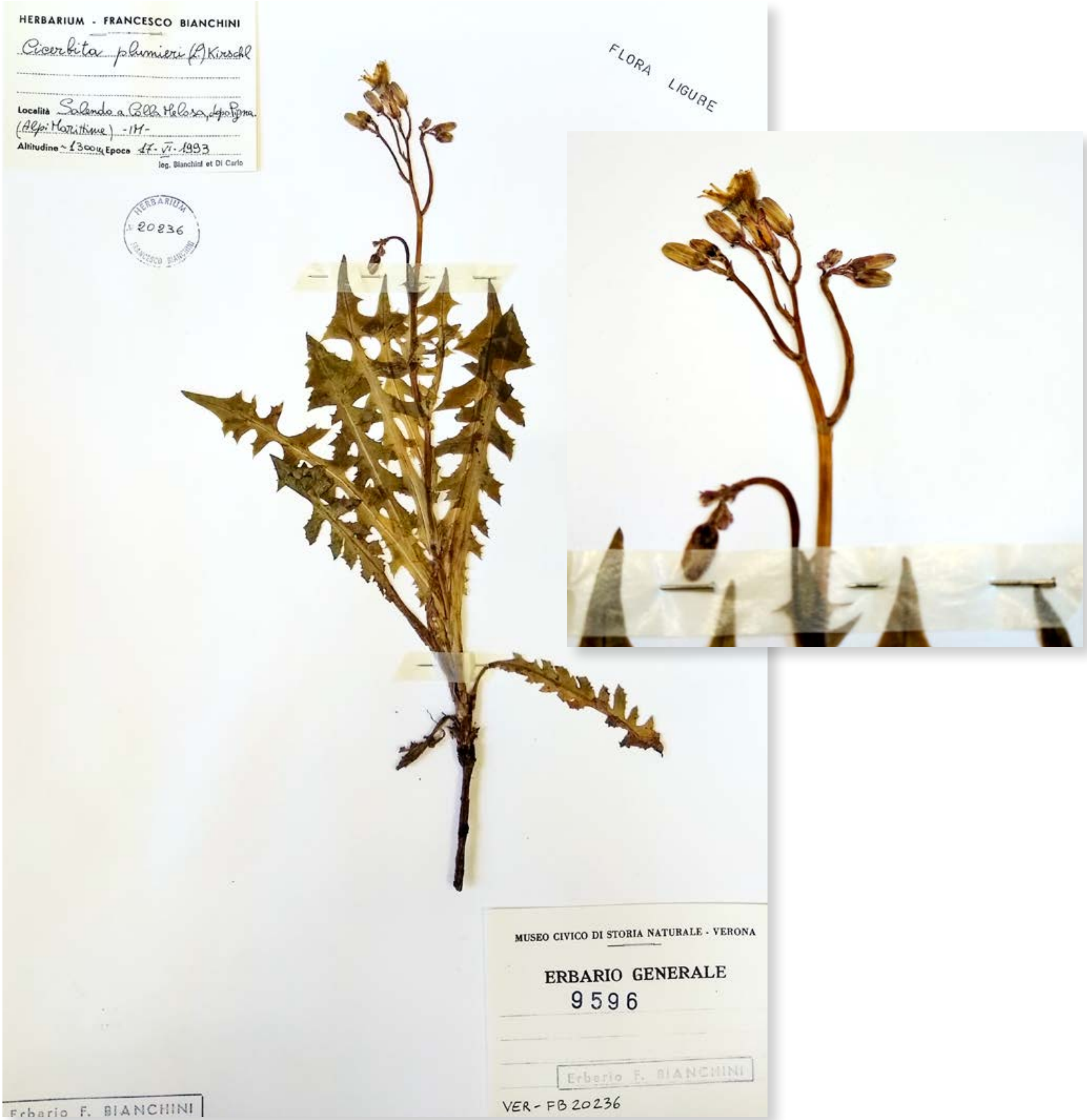
Fig. 1 – Mappa di distribuzione di *Lactuca plumieri* (L.) Gren. & Godr. in Europa occidentale (GBIF.org). In Italia non sono note stazioni di questa specie. Il pallino giallo indica l'unica località italiana dove è stata osservata questa specie

Museo. La determinazione è stata fatta consultando Pignatti (1982) e altre pubblicazioni specialistiche; in particolare per questa specie è stata consultata la flora di Francia e Svizzera di Bonnier e Layens (1934) e la Flora Helvetica (Eggenberg *et al.*, 2018).

Risultati e discussione

Fra il materiale raccolto nel corso della campagna del 1993, è stata confermata la presenza di *Lactuca plumieri* (L.) Gren. & Godr.: la presenza dei tipici fiori blu e il fusto in alto glabro, insieme agli altri caratteri morfologici generali, sono stati determinanti nell'identificazione della specie.

La pianta è stata raccolta il 17 giugno 1993 da due degli autori (FB e FDC) lungo il sentiero che da Colla di Langan (m 1.127 slm) si diparte a NW verso Colla Melosa (m 1.500 ca. slm), dopo circa un chilometro, nel corso di un rilievo in zona di natura boschiva. La località è situata in provincia di Imperia (Liguria), lungo il confine tra i Comuni di Pigna e Triora, a pochi chilometri dal confine con la Francia. Si è tentato di individuare a posteriori il punto esatto di raccolta, in modo da poter associare al campione d'erbario delle coordinate quanto più precise possibili, ma purtroppo l'operazione non è riuscita. Al campione d'erbario sono state quindi associate le coordinate del toponimo "Colla Melosa" (WGS84: 43.98856N; 7.68694E), riportato nel cartellino come la località più prossima al punto di raccolta.



HERBARIUM - FRANCESCO BIANCHINI
Cicerbita plumieri (L.) Kirschl
Località Salendo a Colla Melosa, dopo Pigna. (Alpi Marittime) -IM-
Altitudine ~ 1300 m Epoca 17-VI-1993
leg. Bianchini et Di Carlo

Fig. 2 – Campione d'erbario di *Lactuca plumieri* (L.) Gren. & Godr. (VER)

L'unico campione di *Lactuca plumieri* raccolto è stato archiviato e inserito nell'erbario generale del Museo (VER n. FB20236, Figura 2), erbario che comprende tutti gli erbari di piante vascolari di botanici veronesi, dalla seconda metà del XIX secolo a oggi, ed è un erbario aperto in cui confluiscono tutte le nuove raccolte.

Il campione raccolto costituisce anche l'unico esemplare osservato sul posto dai due autori (FB e FDC). Sarebbe dunque interessante fare un'indagine più approfondita sulla presenza di questa specie nei dintorni del primo ritrovamento e più in generale nelle zone alpine occidentali, soprattutto lungo i confini con Francia e Svizzera dove è presente, per cercare di chiarire se quello osservato e raccolto sia effettivamente solo un esemplare effimero, giunto per caso dalle non lontane stazioni francesi, oppure se siano presenti delle popolazioni stabili anche in territorio italiano.

BIBLIOGRAFIA

AESCHIMANN D., LAUBER K., MOSER D.M., THEURILLAT J.P., 2004. Flora Alpina. 3 voll. *Haupt*, Bern; *Zanichelli*, Bologna.

BARTOLUCCI F., PERUZZI L., GALASSO G., ALBANO A., ALESSANDRINI A., ARDENGHI N.M.G., ASTUTI G., BACCHETTA G., BALLELLI S., BANFI E., BARBERIS G., BERNARDO L., BOUVET D., BOVIO M., CECCHI L., DI PIETRO R., DOMINA G., FASCETTI S., FENU G., FESTI F., FOGGI B., GALLO L., GOTTSCHLICH G., GUBELLINI L., IAMONICO D., IBERITE M., JIMÉNEZ-MEJÍAS P., LATTANZI E., MARCHETTI D., MARTINETTO E., MASIN R.R., MEDAGLI P., PASSALACQUA N.G., PECCENINI S., PENNESI R., PIERINI B., POLDINI L., PROSSER F., RAIMONDO F.M., ROMA-MARZIO F., ROSATI L., SANTANGELO A., SCOPPOLA A., SCORTEGAGNA S., SELVAGGI A., SELVI F., SOLDANO A., STINCA A., WAGENSOMMER R.P., WILHALM T. & CONTI F., 2018. An updated checklist of the vascular flora native to Italy. *Plant Biosystems* 152(2): 179-303. doi: 10.1080/11263504.2017.1419996.

BONNIER G., LAYENS G., 1934. Flore complete de France Suisse et Belgique. 11 voll. Orlhac, Paris.

CONTI F., ABBATE G., ALESSANDRINI A., BLASI C., 2005. An annotated checklist of the Italian vascular flora. Palombi & Partner, Roma: 424 pp.

EGGENBERG S., BORNAND C., JUILLERAT P., JUTZI M., MOHL A., NYFFELER R., SANTIAGO H., 2018. Flora Helvetica. Guide d'excursions. Haupt, Bern.: 816 pp.

PIGNATTI S., GUARINO R:, LA ROSA M., 2018. Flora d'Italia, II edizione, 4 voll. Edagricole-Edizioni Agricole di New Business Media, Bologna.

SITOGRAFIA

GBIF.org (05 July 2021) GBIF Occurrence Download https://doi.org/10.15468/dl.fwtw3y

Bollettino del Museo Civico di Storia Naturale di Verona, 45, 2021 Botanica Zoologia: 9-20

Nuovi dati sulla distribuzione di *Austropotamobius pallipes* (Lereboullet, 1858) (Crustacea: Decapoda: Astacidae) nell'Est veronese e una sintesi delle conoscenze per la Provincia di Verona

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ABSTRACT

The authors provide the updated distribution of the white-clawed crayfish, Austropotamobius pallipes *(Lereboullet, 1858), a species included in the Annexes II and V of the Habitats Directive (Directive 92/43/EEC), in the Tramigna-Alpone basin, Eastern part of Verona Province, Northern Italy. This study provides new presence records of the species in the Municipalities of Soave, Monteforte D'Alpone, Cazzano di Tramigna, Tregnago and Roncà. Furthermore, this study includes the list of the sites in the Verona Province where the species is or was present; the dataset obtained was assembled on the base of literature review, personal communications to the Authors and Citizen Science observations. Finally, new distribution data for the two allochthonous crayfish* Procambarus clarkii *(Girard, 1852) and* Orconectes limosus *(Rafinesque, 1817) are given.*

Key words: *Biodiversity, conservation, faunistic, nature, white-clawed crayfish, Verona Province, WBA, World Biodiversity Association.*

RIASSUNTO

Gli autori forniscono un quadro distributivo aggiornato del gambero di fiume europeo, *Austropotamobius pallipes* (Lereboullet, 1858), specie di interesse comunitario ai sensi della Direttiva Habitat 92/43/CEE, nei bacini del Torrente Tramigna e del Torrente Alpone (porzione orientale della Provincia di Verona). Lo studio segnala la presenza di *A. pallipes* in nuove stazioni nei territori comunali di Soave, Monteforte D'Alpone, Cazzano di Tramigna, Tregnago e Roncà. È inoltre fornita una lista delle località veronesi in cui la specie è od era presente, costruita a partire dalla revisione della letteratura, da comunicazioni personali e da dati derivanti da Citizen Science. Infine, sono riportati anche nuovi dati distributivi di due specie invasive, *Procambarus clarkii* (Girard, 1852) e *Orconectes limosus* (Rafinesque, 1817).

Parole chiave: Biodiversità, conservazione, faunistica, natura, gambero di fiume, Provincia di Verona, WBA, World Biodiversity Association.

INTRODUZIONE

Il gambero di fiume europeo, *Austropotamobius pallipes* (Lereboullet, 1858), è tra le specie più minacciate in Europa e pertanto incluso nella lista rossa IUCN sotto la categoria "endangered" (Füreder *et al.*, 2010). Il suo areale di distribuzione trova il limite orientale in Montenegro, il limite occidentale in Spagna e il limite settentrionale in Scozia (Manenti *et al.,* 2019). Sebbene siano ancora presenti abbondanti popolazioni in alcune aree limitate, nel complesso la densità di *A. pallipes* è diminuita drasticamente, la sua distribuzione è stata fortemente ridotta tanto che, in molti siti, diverse popolazioni risultano estinte (Holdich *et al.,* 2009). Cause della riduzione sono da imputare all'azione congiunta di più fattori, tra i quali spiccano l'inquinamento delle acque e la diffusione di specie invasive di gamberi alloctoni come *Procambarus clarkii* (Girard, 1852) e *Orconectes limosus* (Rafinesque, 1817), entrambe di origine nordamericana (Manenti *et al*., 2014). Queste specie sono soprattutto responsabili della diffusione della peste del gambero (*Aphanomyces astaci* Schikora, 1906), che ha recentemente causato drammatiche estinzioni delle popolazioni di gamberi europei (Manenti *et al*., 2019). Altri fattori di rarefazione di *A. pallipes* sono la modifica della funzionalità dei corsi d'acqua, i prelievi idrici non autorizzati, le attività estrattive sugli alvei dei corsi d'acqua, gli sbarramenti e l'utilizzo delle risorse idriche per la produzione idroelettrica (Stoch, 2014). *Austropotamobius pallipes* è una specie di interesse comunitario ai sensi della Direttiva 92/43/CEE (Allegato II "Specie animali e vegetali d'interesse comunitario la cui conservazione richiede la designazione di zone speciali di conservazione"), è inserita in Appendice 3 della Convenzione di Berna (Convenzione sulla Conservazione della Vita Selvatica e degli Habitat naturali in Europa) e risulta in forte calo numerico in tutto il suo areale italiano (Genovesi *et al.*, 2014), in particolare nella regione biogeografica alpina (Scalici *et al.*, 2016). L'interesse di questa specie dal punto di vista naturalistico è anche dato dal fatto che la sua presenza rappresenta un importante segnale in riferimento alla qualità delle acque. Il gambero europeo, infatti, è considerato un buon bioindicatore avendo bassa tolleranza verso i prodotti fitosanitari impiegati in agricoltura (Favaro *et al.,* 2010).

Austropotamobius pallipes era storicamente diffuso nella parte nordorientale della provincia di Verona dove era comunemente oggetto di pesca da parte della popolazione locale. La sua presenza era ben documentata anche nella pianura veronese sin dalla comparsa della peste del gambero (Martinati, 1861), mentre non era segnalato, già a inizio secolo, nell'alveo del Fiume Adige (Sormani Moretti, 1903).

Per quanto riguarda le due specie invasive sopracitate, *P. clarkii* è presente nella provincia scaligera dal 1989 (Scovacricchi e Alfarè, 2016) mentre la prima segnalazione di *O. limosus* risale al 1994 (Confortini e Natali, 1995). Entrambi i taxa risultano diffusi nelle acque correnti di risorgiva della media e bassa pianura e, in modo limitato, in quelle salmonicole a monte del Fiume Adige, oltre che nelle acque lacustri, come il Lago di Garda (Confortini, 2014).

Sulla base di dati pregressi ottenuti nel 2014-2020 nell'ambito di azioni di monitoraggio della qualità delle acque superficiali, al fine di valutare gli impatti ambientali dell'agricoltura sul territorio (Caoduro, 2020), durante le quali è stata rilevata, dopo molti anni dalle ultime segnalazioni, la presenza di *A. pallipes* in alcuni corsi d'acqua nei Comuni di Soave e Roncà, nel 2020 è iniziato uno studio sulla presenza del gambero di fiume nel territorio del Consorzio del vino Soave (Comuni di Soave, Roncà, Monteforte d'Alpone, Tregnago, Montecchia). Il presente lavoro riporta i dati ottenuti nel corso di questa indagine preliminare (Tabelle 1 e 2), oltre a fornire un quadro riassuntivo delle segnalazioni del gambero nel territorio veronese, a partire da dati storici e con l'aggiunta di segnalazioni più recenti da letteratura e da dati inediti (Tabella 3).

Materiali e metodi

Inquadramento storico geografico dell'area di studio

L'area interessata dal presente studio è situata nella parte orientale della Provincia di Verona, a circa 20 km a Est dal Capoluogo (Figura 1). Il territorio è caratterizzato da dorsali collinari che si estendono in direzione Nord-Sud verso la pianura, intervallati da valli strette e lunghe (Sauro, 2018). I due bacini idrografici interessati dall'indagine sono quelli della Val Tramigna e della Valle dell'Alpone. La Val Tramigna, compresa tra le più ampie valli del Torrente Illasi e del Torrente Alpone, è scavata nella successione carbonatica terziaria-eocenica e trae il proprio nome dall'omonimo torrente. Si tratta di una valle stretta e profondamente incisa nella parte settentrionale, mentre verso meridione assume una configurazione più aperta, con una ampiezza di quasi 3 km nel tratto corrispondente al centro abitato di Soave. Per metà circa della sua lunghezza, fin poco sopra il paese di Cazzano di Tramigna, il torrente, denominato Tramegnola, si presenta come un solco profondo con il letto inciso nei calcari del Cretaceo. La sorgente è localizzata in prossimità del Monte Fajardam (837 m s.l.m.) e dà origine a un ruscello che scorre in superficie per un tratto limitato, fino a sparire nelle ghiaie di fondovalle, a un paio di chilometri a Nord di Cazzano. In corrispondenza del centro abitato di Cazzano, a 96 m s.l.m., le acque di falda riemergono nel cosiddetto Lago della Mora. Il torrente che da qui si origina è lungo solo 12 km e tocca diversi paesi, tra i quali Costeggiola, San Vittore, Soave e San Bonifacio dove trova confluenza nel Fiume Alpone (Sambugaro *et al.*, 2014).

La Valle dell'Alpone si sviluppa in direzione Nord-Sud ed è percorsa dall'omonimo torrente; presenta una forma allungata e stretta nella parte settentrionale, larga e aperta in quella meridionale, fino alla pianura. Confina a Est con la Valle del Chiampo, e a Ovest con la Val Tramigna e la Val d'Illasi. Il Torrente Alpone nasce nella Lessinia orientale, in Comune di Vestenanova, sulle pendici del Monte Purga di Bolca. Ha una lunghezza di circa 38 km e sbocca nell'Adige, nei pressi di Albaredo d'Adige (Salin *et al.*, 2014). I due bacini si differenziano

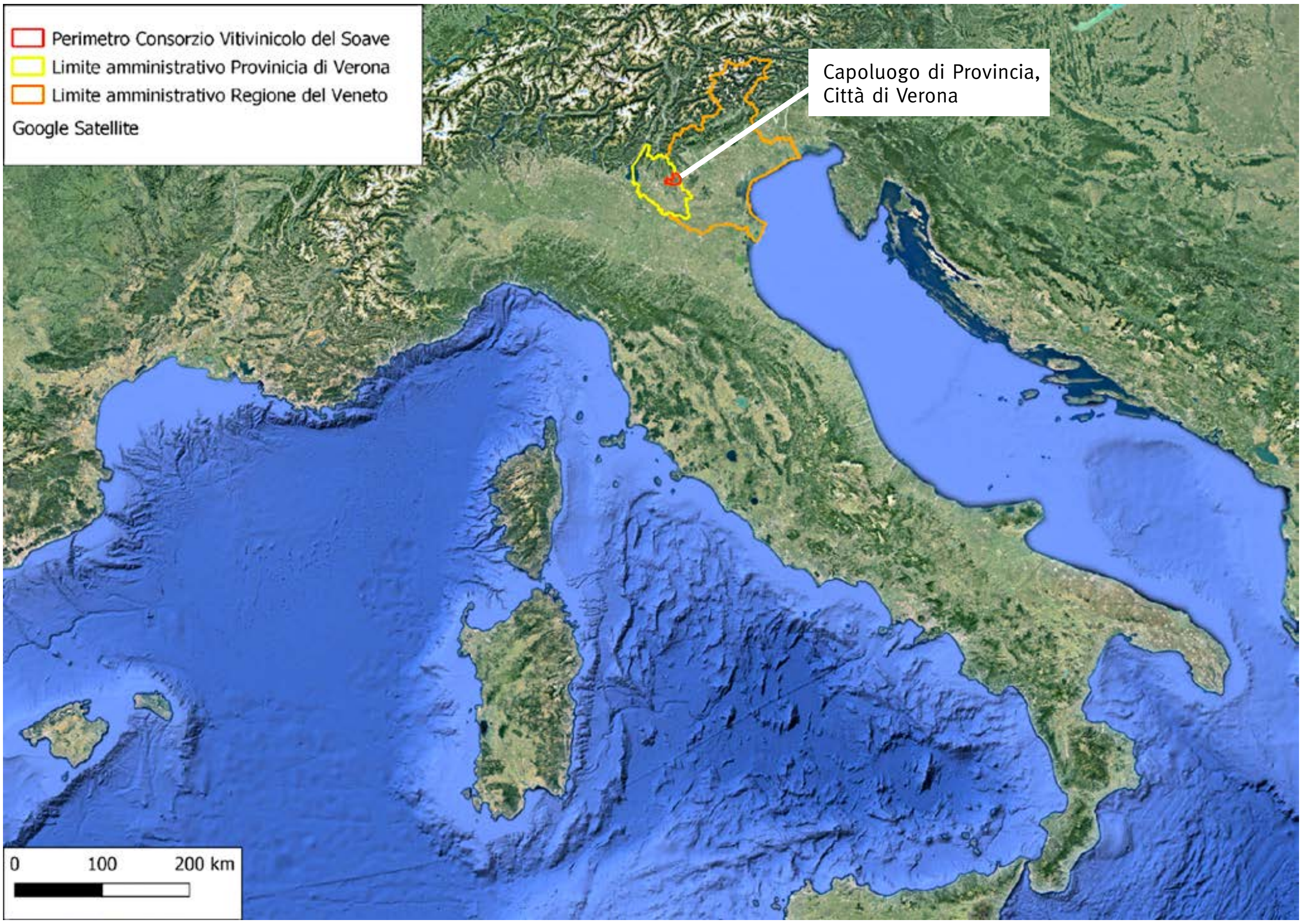

Fig. 1 – Rappresentazione dell'area di studio su scala nazionale. In rosso il Consorzio Vitivinicolo del Soave, in giallo la Provincia di Verona, in arancione la Regione del Veneto

anche dal punto di vista geologico: infatti, il primo è costituito da rocce prevalentemente di origine carbonatica, mentre il secondo da rocce di origine vulcanica (Benciolini e Zorzin, 2020).

Il territorio ascrivibile al Consorzio Vitivinicolo del Soave occupa una superficie di circa 13.600 ha, di cui 4.500 ha circa sono all'interno del bacino del Torrente Alpone e 2.000 ha circa nel bacino del Torrente Tramigna (Figure 2 e 3). Il territorio del Soave è stato riconosciuto da parte del Ministero dell'Agricoltura come "Paesaggio Rurale di Interesse Storico" e, più recentemente, dalle Nazioni Unite come primo sito italiano GIAHS – Globally Important Agricultural Heritage System (Caoduro, 2020).

Ricerca sul campo

Le attività di campionamento sono state precedute dalla individuazione dei corsi d'acqua potenzialmente idonei all'indagine attraverso un'analisi dell'idrografia regionale in formato digitale, scaricata dall'Infrastruttura dei Dati Territoriali della Regione Veneto (Figure 1, 2 e 3). Gli shape file importati in ambiente GIS sono:

1. Corsi d'acqua non interessati dal vincolo paesaggistico della Provincia di Verona ai sensi del D.Lgs. 42/2004;
2. Corsi d'acqua parzialmente interessati dal vincolo paesaggistico della Provincia di Verona, iscritti negli elenchi delle acque pubbliche ai sensi dell'art. 142, comma 1, lett. c) del D.Lgs. 42/2004, aggiornato con le modifiche conseguenti alla Dgr. n. 1496 del 31 luglio 2012 e Dgr. n. 1638 del 17 settembre 2013;
3. Corsi d'acqua interessati dal vincolo paesaggistico della Provincia di Verona ai sensi del D.Lgs. 42/2004.

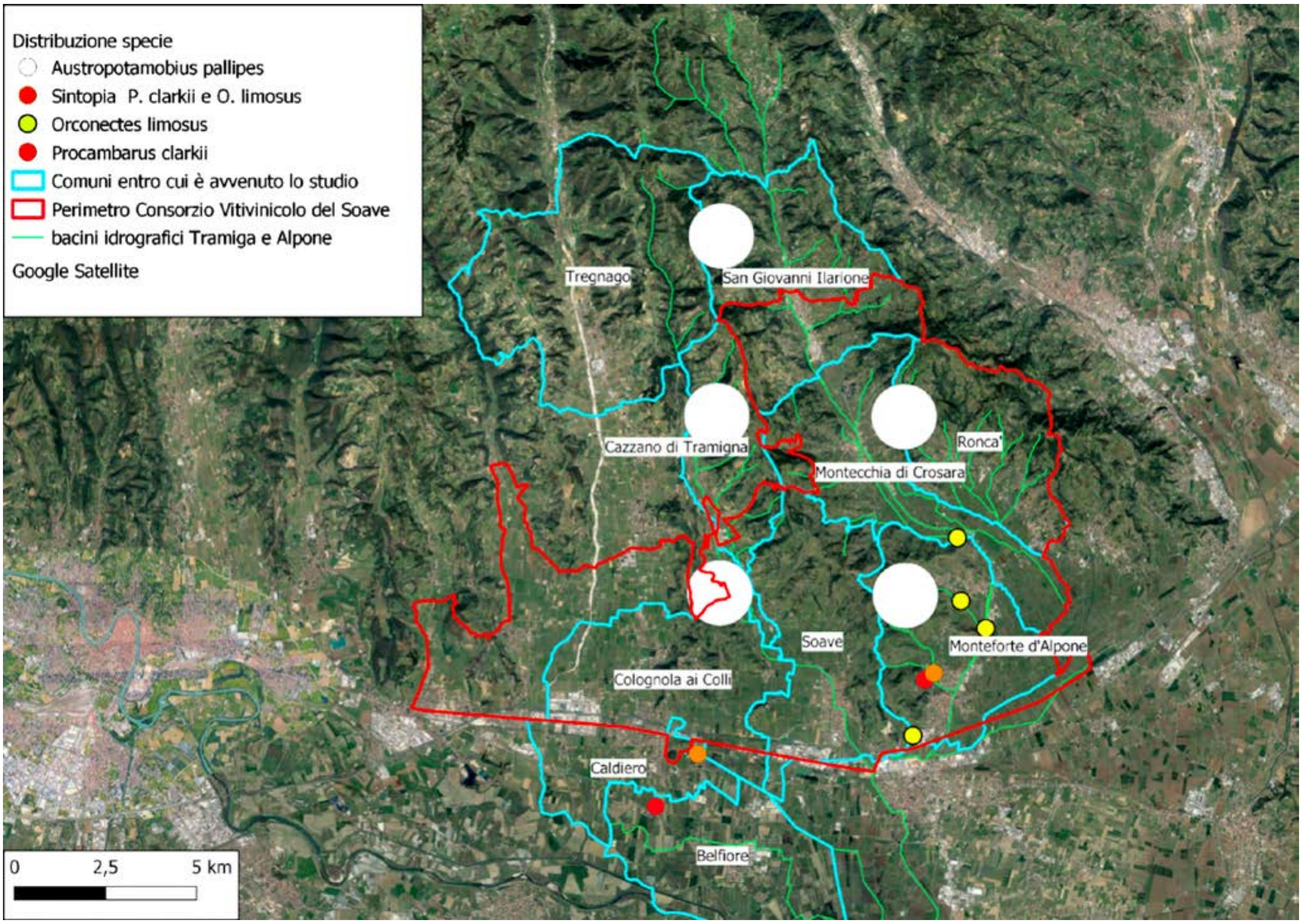

Fig. 2 – Distribuzione del gambero di fiume europeo e delle due specie alloctone nel Consorzio Vitivinicolo del Soave e nei Comuni che ne fanno parte. La dimensione dei punti relativi alla distribuzione di *A. pallipes* è volutamente ingrandita per non indicare la località precisa di rinvenimento della specie (*cfr*. Spairani, 2005)

Successivamente gli stessi file sono stati caricati su smartphone e importati nell'applicazione per Android "QField"; tale applicazione permette di visualizzare la propria posizione in relazione alla cartografia importata su smartphone. Questa operazione ha consentito di raggiungere con relativa facilità i corsi d'acqua oggetto di indagine.

L'attività sul campo è stata condotta nei mesi di ottobre e novembre del 2020 in modo sistematico con 17 uscite nelle ore diurne. La ricerca è stata condotta attivamente, dapprima osservando la presenza di eventuali gamberi in attività sul letto del corso d'acqua, perlustrando l'area alla ricerca di gamberi morti e/o resti di essi (esuvie incluse) per poi cercare gli animali nei loro possibili ripari (sotto le pietre del fondo, in cavità, ecc.) come indicato in Ghia *et al*. (2014), Scalici *et al*. (2016), Cassol *et al*. (2018) e Aquiloni *et al*. (2019). La presenza di stadi giovanili è stata rilevata attraverso la perlustrazione dei gruppi di radici presenti in vicinanza degli argini o negli accumuli di foglie sul fondo (Aquiloni *et al*., 2019). All'occorrenza, in corsi d'acqua di profondità superiore ai 30 cm, è stato utilizzato un retino immanicato, con maglia di 0,5 cm per la raschiatura del fondo e delle rive del corpo idrico. Le procedure di studio hanno previsto la sanificazione delle eventuali attrezzature utilizzate dopo ogni sopralluogo, come indicato in Ghia *et al*. (2014).

Per ogni località studiata, è stata redatta una scheda di rilievo contenente i seguenti campi: località, data, quota, comune, coordinate geografiche, numero di individui, età, note, rilevatore. Le coordinate sono state rilevate mediante GPS Garmin Dakota 20; i dati poi sono stati inseriti mediante digitalizzazione in ambiente GIS.

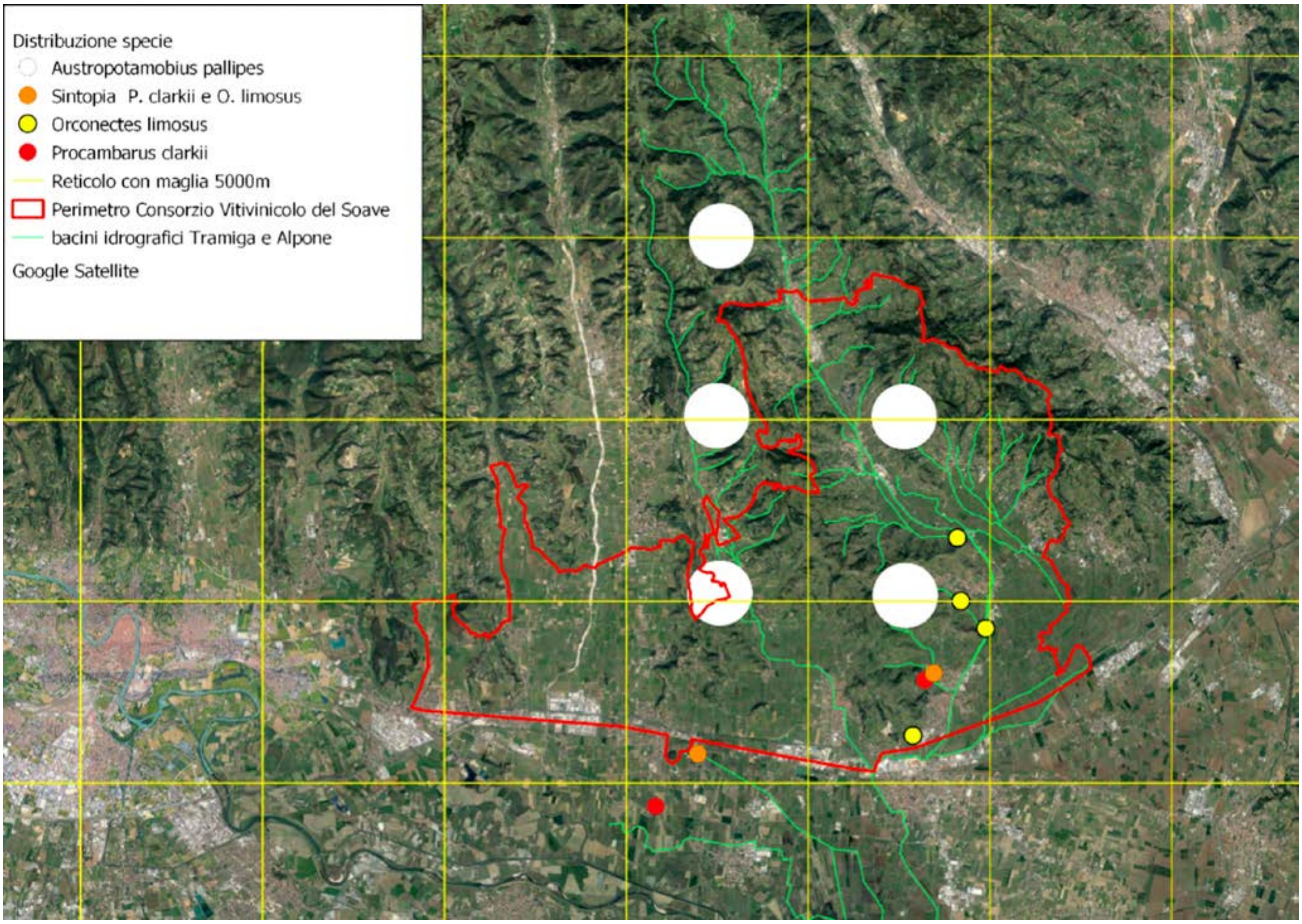

Fig. 3 – Distribuzione del gambero di fiume europeo e delle due specie esotiche nel Consorzio Vitivinicolo del Soave. La dimensione dei punti relativi alla distribuzione di *A. pallipes* è volutamente ingrandita per non indicare la località precisa di rinvenimento della specie (*cfr.* Spairani, 2005).

Di seguito è stata attribuita a ogni corpo idrico indagato una tipologia di classificazione, basata sulle seguenti categorie: corpi idrici naturali, corpi idrici artificiali (canali irrigui, di scolo o ad uso promiscuo, fossati di origine antropica), laghetti/zone umide (Cassol *et al.*, 2018).

Nel corso di questa fase preliminare non sono state effettuate indagini chimico-fisiche e biologiche sulla qualità delle acque; tali indagini sono previste in una fase successiva della ricerca. Inoltre, non sono state raccolte altre informazioni relative alla parte più settentrionale del bacino dell'Alpone, esterna al Consorzio del Soave, che sarà indagata in seguito.

Tutti i dati di presenza del gambero europeo e degli alloctoni sono stati georeferenziati; tuttavia, in considerazione del particolare *status* protezionistico di *A. pallipes* e della relativa legislazione di tutela, non viene fornito in questo contesto la localizzazione precisa delle stazioni individuate, come suggerito in Spairani *et al.* (2005).

Ricerca bibliografica

La ricerca è stata svolta al fine di verificare e raccogliere le conoscenze faunistiche relative al gambero di fiume europeo nel territorio della Provincia di Verona. Uno strumento essenziale a tale scopo si è rivelato il motore di ricerca Google Scholar, mediante l'utilizzo di parole chiave unitamente a operatori booleani AND, OR, NOT sia per la letteratura in italiano che in inglese. Sono stati consultati, inoltre, gli archivi dell'Accademia di Agricoltura, Scienze e Lettere di Verona, della Biblioteca Civica di Verona e del Museo Civico di Storia Naturale di Verona. L'indagine è stata integrata, infine, mediante la piattaforma di Citizen Science INaturalist, in riferimento alla Provincia di Verona, tramite la verifica delle segna-

Tabella 1 – Comuni in cui sono state individuate le stazioni di *A. pallipes* durante la presente ricerca (**A** = adulto, **J** = giovane)

Data	**Comune**	**Numero di individui**	**Tipologia di corpo idrico**
31/10/2019	Roncà	1A -1J	naturale
30/5/2020	Soave	1A	naturale
6/10/2020	Cazzano di Tramigna	1A-1J	naturale
7/10/2020	Cazzano di Tramigna	3J	naturale
9/10/2020	Tregnago	5J	naturale
9/10/2020	Cazzano di Tramigna	2 morti	naturale
14/10/2020	Monteforte d’Alpone	1A	naturale

Tabella 2 – Località in cui sono state individuate le stazioni delle specie alloctone durante la presente ricerca (**A** = adulto, **S** = subadulto, **J** = giovane)

Data	**Comune**	**Località**	**Coordinate**	**Specie**	**Numero**	**Tipologia di corpo idrico**
5/10/2020	Belfiore	Pressolvino	N 45°23’48.20” E 11°10’55.00”	*P. clarkii*	1A	di scolo
5/10/2020	Caldiero	Terme di Giunone	N 45°24’33.95” E 11°11’49.89”	3 *P.clarkii,* 2 *O. limosus*	1A-1S- 1J *P. clarkii* 2J *O. limosus*	fossato
9/10/2020	Monteforte d’Alpone	Colombara	N 45°25’40.04” E 11°16’51.09”	*P. clarkii*	3A	fossato
13/10/2020	Monteforte d’Alpone	Casarsa	N 45°26’18.55” E 11°17’58.47”	*O. limosus*	1J	naturale
13/10/2020	Montecchia	C. Core	N 45°27’39.94” E 11°17’25.90”	*O. limosus*	5J	naturale
17/10/2020	Monteforte d’Alpone	Colombara	N 45°25’34.09” E 11°16’39.49”	2 *O. limosus* 1 *P. clarkii*	3A	fossato in cemento
17/10/2020	Soave	I Capuccini	N 45°24’44.91” E 11°16’22.53”	*O. limosus*	4A - 2S - 3J	fossato
26/10/2019	Monteforte d’Alpone	Palù	N 45°26’43.60” E 11°17’28.13”	*O. limosus*	2A	naturale

lazioni, da foto, da parte degli autori del presente studio. Queste informazioni sono state raggruppate in Tabella 2.

Risultati

Nel corso della presente ricerca sono stati raccolti i dati di presenza di *A. pallipes* (Tabella 1) e degli alloctoni *P. clarkii* e *O. limosus* (Tabella 2) all'interno dei Torrenti Tramigna e Alpone e loro affluenti per un totale di 27 stazioni (Figure 2 e 3).

In questa prima fase della ricerca, *A. pallipes* è stato segnalato in sette diverse località, dal fondovalle (127 m s.l.m. nel Comune di Monteforte d'Alpone) fino a circa 400 m di quota nel Comune di Tregnago. La sua presenza è stata inoltre rilevata nel Comune di Cazzano di Tramigna alla quota di 260 m s.l.m. e a quota 130 m s.l.m., nel Comune di Soave alla quota di 170 m s.l.m. e nel Comune di Roncà alla quota di 128 m s.l.m. La quota prevalente di ritrovamento (mediana) è pari a 150 m s.l.m. (quota media: 192 m s.l.m.). Sono stati rinvenuti due individui morti in stato di decomposizione in un'altra località del Comune di Cazzano di Tramigna a 177 m s.l.m. in presenza di acqua stagnante.

Procambarus clarkii, è stato rinvenuto dal fondovalle a 25 m s.l.m. in località Pressolvino in Comune di Belfiore, e a circa 40 m di quota in località Colombara in Comune di Monteforte d'Alpone. La quota prevalente (mediana) è pari a 32 m s.l.m.

Orconectes limosus è stato segnalato dal fondovalle a 30 m s.l.m. in località I Capuccini in Comune di Soave, e a circa 50 m di quota in Località C. Core in Comune di Montecchia di Crosara. La quota prevalente (mediana) è pari a 38 m s.l.m.

Nella successiva tabella 3 sono riportati anche i dati ricavati dalla piattaforma INaturalist e da altre fonti bibliografiche e online.

Tabella 3 – Distribuzione nel tempo di *Austropotamobius pallipes* in diverse aree della Provincia di Verona

Fonte	Anno	Località	Comune
WWF Veronese (2020)	2020	Parco delle Cascate di Molina	Molina (VR)
Comunicazione personale di Luca Longo (Associazione Italiana Naturalisti)	2020	Giazza nel Rio Fraselle, sul Monte Baldo nel Rio Pissotte, in Valsorda a Nord di Fumane, nel Rio Bagatel (Vestenavecchia), nella Valle dei Molini a Garda, nel Vajo della Marciora	Lessinia e Baldo (VR)
Comunicazione personale di Andrea Crobu, Mattia Dal Zovo (APPV)	2019	Vajo dei Piombini	Vestenanova (VR)
Comunicazione personale di Andrea Crobu, Mattia Dal Zovo (APPV)	2018-2019	Case Santa Maria	Roncà (VR)
INaturalist https://www.inaturalist.org/observations/64857456	2020	Sorgente Albi di Brione	Malcesine (VR)
INaturalist https://www.inaturalist.org/observations/6048750	2017	San Giorgio ai Salici	Sona (VR)
INaturalist https://www.inaturalist.org/observations/5717310	2017	San Giorgio ai Salici, Contrada Turco	Sona (VR)
Comunicazione personale di Andrea Crobu, Mattia Dal Zovo (APPV)	2014	Montorio	Montorio (VR)

segue Tabella 3 – Distribuzione nel tempo di *Austropotamobius pallipes* in diverse aree della Provincia di Verona

Fonte	**Anno**	**Località**	**Comune**
Comunicazione Personale di Francesca Dall'Ora (Legambiente Circolo "il Tasso")	2014	Valle dei Mulini	Costermano sul Garda (VR)
www.montorioveronese.it APPV	2014	La Parola	Montorio (VR)
Comunicazione personale di Dall'O', Cavallini, Dall'Ora (WWF Veronese e Legambiente Circolo "il Tasso")	2013	Val Strova	Costermano (VR)
Carta Ittica Provincia di Verona, 2012	2012	Bagattei	Vestenanova (VR)
Comunicazione personale di Giovanni Bombieri (WBA)	2010	Parco delle Cascate di Molina	Molina (VR)
Sentiero naturalistico il gambero di fiume nella Val dei Mulini (Boni *et al.*, 2009)	2009	Valle dei Mulini, Fornase, Pizzon e Caprino	Costermano e Caprino (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Ianilli	2002	Santa Cristina	Parona (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Latella	2002	Rio S. Ambrogio	Mezzane (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Zanini	2001	Villa Monastero	Parona (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Longo	1999	Parona	Parona (VR)
Confortini, 1994 *(dato inedito)*	1993-1994	VajoValenassi a Peri, Vajo Casarole a Sant'Anna d'Alfaedo, Progno di Breonio a Fumane, Rio Mondrago a Sant'Anna d'Alfaedo, Progno di Marano in Valpolicella, Vajo dei Covoli a Velo Veronese, Vajo di Valtanara a Selva di Progno, Torrente Alpone a San Giovanni Ilarione, Rio Bagattel a Badia Calavena, Torrente Tramigna a Cazzano di Tramigna, Rio Verlè a Soave, Valle della Chiesa a Roncà, Torrente Gusa a San Zeno di Montagna	Lessinia e Baldo (VR)
Longo e Magagna, 1992	1992	Vajo dell'Orsa, Torrente Fraselle, Vajo dell'Orsa, Alpone e suoi affluenti	Lessinia e Baldo (VR)
Zanini, 1992	1992	Val Strova, Val dell'acqua	Costermano (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Osella	1986	Sorgente del Dugal	Mezzane di Sotto (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Osella	1986	Val Sorda	Fumane (VR)

segue Tabella 3 – Distribuzione nel tempo di *Austropotamobius pallipes* in diverse aree della Provincia di Verona

Fonte	**Anno**	**Località**	**Comune**
Oppi, 1986	1985	Valle della Chiesa	Roncà (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Malesani	1983	Laghetto Squarà	Montorio (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Sette?	1983	Reletino	Malcesine (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Mingione	1972	Vajo dei Progni	Fumane (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Zanetti	1969	Dintorni di Fumane	Fumane (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - ID Froglia, 1978	1966	Piazza d'Acqua	Cadidavid (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - Mingione - Caobelli - ID Albrecht, 1978	1966	Val Vilmezzano	Caprino (VR)
Reperto conservato al Museo Civico di Storia Naturale di Verona - ID Froglia, 1978	1956	Ponte di Veja	Grezzana (VR)
Touring Club Italiano, Fondazione italiana Buon Ricordo, 1931	1931	Fumane	Fumane (VR)
Sormani Moretti, 1903	1903	Lago di Garda, Montorio, Monteforte, Montecchio, Cazzano di Tramigna, Santa Maria in Stelle, Mizzole, Negrar, Mezzane di Sotto, Pazzon, Castelcerino, Bellori, Trezzolano, Vestenanova, Val Tanara, Val dei Gamberi – Badia Calavena, Val dei Rugoloti, Molina, Salaorno, Val del Covolo, Roverè	Lessinia e Baldo (VR)
Martinati, 1861	1861	Montorio, Palù, Belfiore, Fiume Tertaro, Torrente Tramigna, Zevio, Persacco, Vallese, Raldon, San Giovanni Lupatoto, Buttapietra, Oppeano, Bionde di Zevio, Cerea, Casaleone, Ferrazze di San Matino, Albaredo, Fiume Fibbio, Fiume Antanello, Fossa Balbi, Condotto Brà, Fossa Bongiovanni, Fossa Crea, Dogale Fontane, Serega e Valle Zerpana	Pianura veronese (VR)
Brugnoli, 2018	1838	Lago di Garda	Lago di Garda
Valerini, 1586	1586	Montorio	Montorio (VR)

Nel corso delle ricerche è stata rilevata la presenza, in simpatria con *A. pallipes*, di vertebrati di interesse naturalistico: tre stazioni di Ululone dal ventre giallo, *Bombina variegata* (Linnaeus, 1758), otto di Salamandra pezzata, *Salamandra salamandra* (Linnaeus, 1758), una di Tritone alpestre, *Ichtyosaura alpestris* (Laurenti, 1768), cinque di Ghiozzo padano, *Padogobius bonelli* (Bonaparte, 1846), due di Spinarello, *Gasterosteus aculeatus* Linnaeus, 1758) e una di Tritone crestato, *Triturus carnifex* (Laurenti, 1768) sintopico con Tritone punteggiato, *Lissotriton vulgaris* (Linnaeus, 1758) e Rana di Lataste, *Rana latastei* Boulenger, 1879).

Discussione

Il quadro distributivo risultante da questa fase preliminare della ricerca dimostra come *A. pallipes* sia tutt'ora presente nella parte orientale della Provincia di Verona, sebbene piuttosto localizzato e con popolazioni non numerose. Considerando che le ricerche sono avvenute alla fine della stagione di attività della specie e in condizioni non ottimali per il contatto, ovvero durante le ore diurne, è plausibile che la reale presenza e abbondanza della specie nei bacini investigati sia stata sottostimata.

Sebbene non vi siano dati aggiornati sulla distribuzione della specie, per quanto concerne la Provincia di Verona e il Veneto meridionale, al di fuori di quelli citati nel presente studio, è probabile che altre popolazioni si potranno individuare in aree altocollinari o montane, all'interno degli affluenti, in tutta la parte Nord dei bacini del Torrente Alpone, Illasi e Mezzane e, nel proseguo del Progetto, nelle restanti valli della Lessinia, a Est e a Ovest dell'area indagata.

Le condizioni favorevoli alla presenza di *A. pallipes* sono legate a un flusso idrico vitale con acqua corrente che permane per buona parte dell'anno, limpida, fresca e ben ossigenata (Bruno *et al.*, 2018). *Procambarus clarkii* predilige habitat diversi, caratterizzati da paludi e acquitrini, sia con acque dolci o salmastre, calde e con scarsa ossigenazione (Morpurgo *et al.*, 2010). *Orconectes limosus* preferisce invece acque a lento scorrimento, tipiche di laghi e stagni, anche con acqua di qualità scadente o inquinata (Mazzoni *et al.*, 2004).

Austropotamobius pallipes vive in corsi d'acqua con scarsa o nulla presenza di ittiofauna, essendo i salmonidi come la trota iridea, *Oncorhynchus mykiss* (Walbaum, 1792), e la trota fario, *Salmo trutta* Linnaeus, 1758), i principali predatori della specie (Bruno *et al.*, 2018). L'uso del suolo deve prevedere pratiche agricole sostenibili, essendo la specie molto sensibile a sostanze inquinanti come gli antiparassitari che possono alterare il chimismo dei corsi d'acqua (Favaro *et al.*, 2010). Appare ad oggi difficile prevedere come le zone in cui *A. pallipes* è ancora presente, possano essere colonizzate dalle due specie invasive, a causa della temperatura dell'acqua non ottimale alla loro sopravvivenza, sebbene vi siano casi di presenza di *P. clarkii* in area alpina, come nel Lago di Lagolo (TN) a 950 m s.l.m. e di *O. limosus* nel Lago di Caldonazzo, nel Lago di Levico a una quota media di 440 m s.l.m. e nei Laghi di Canzolino e Madrano a una quota media di 500 m s.l.m. (Bruno *et al.*, 2018). Ulteriore fattore che potrebbe aiutare a prevenire la diffusione delle specie aliene dal fondo valle verso le zone a quote più elevate è la presenza di barriere naturali come cascate e presenza di acqua non regolare durante l'anno (Manenti *et al.*, 2014; Bonelli *et al.*, 2017).

Conclusioni

La presenza di *Austropotamobius pallipes* pone importanti obiettivi per la conservazione e la salvaguardia degli ambienti che ospitano la specie. Al fine di mantenere tali caratteristiche è pertanto necessario adottare e mantenere modelli di gestione del territorio più attenti alla tutela degli habitat e alla riduzione delle pressioni ambientali derivanti da forme di antropizzazione diffusa e agricoltura intensiva.

In particolare, per quest'ultima è auspicabile l'impiego di protocolli di sostenibilità ambientale finalizzati anche alla conservazione delle qualità chimico-fisiche e biologiche delle acque superficiali. A tale scopo il mantenimento e l'ampliamento delle aree verdi tampone attorno ai corsi d'acqua costituirebbero una prima misura di tutela. Allo stato attuale conosciamo ancora troppo poco circa i popolamenti *A. pallipes* nell'area studiata; per questo motivo si auspica che nei prossimi anni siano incrementati numero e qualità dei dati raccolti al fine di poter meglio definire un quadro d'insieme. In particolare, ulteriori indagini potranno ampliare la ricerca ai bacini idrici circostanti, caratterizzare le acque secondo parametri chimico-fisici a livello puntuale e, ove possibile, definire relazioni e grado di isolamento genetico tra le popolazioni dell'Est Veronese. Parallelamente sarà importante mantenere alta la soglia di attenzione nei confronti delle specie invasive.

In pianura, dove si sono insediate le specie alloctone di gambero, è auspicabile ricreare habitat fluviali complessi così da favorire processi di fitodepurazione e autodepurazione delle acque e garantire condizioni favorevoli agli antagonisti naturali di queste specie (uccelli, mammiferi, pesci). Infine, è da considerare la possibilità, come già sta avvenendo in Lombardia, Trentino, Abruzzo, Molise e Friuli (Zanetti *et al.,* 2012; Ghia *et al.*, 2014; Bruno *et al.*, 2018), di mettere in atto azioni di controllo diretto delle specie alloctone e prevedere attività di allevamento in cattività di *A. pallipes* per ripopolamento in aree vocate, così da evitare l'estinzione locale dovuta alla mancanza di connessioni tra popolazioni in aree amene e ricche di barriere naturali (Manenti *et al.*, 2019).

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Bibliografia

AQUILONI L., CARICATO G., CHIESA S, CIUTTI F., DÖRRA. J.M., ELIA C., FEA G., GHIA D., INGHILESI A., INNOCENTI G., MAZZA G., PREARO M., SCALICI M., TRICARICO E., 2019. Linee guida per la conoscenza e il corretto monitoraggio dei Decapodi Dulcicoli in Italia. Associazione Italiana Ittiologi Acque Dolci: 91 pp.

BONI R., DALL'ORA F., SCALA R., 2009. Sentiero naturalistico "Il Gambero di Fiume nella Val dei Mulini". Verona: 48 pp.

BENCIOLINI G., ZORZIN R., 2020. I Suoli: In: AA.VV., 2020. Soave terroir. Le 33 unità geografiche aggiuntive del Soave. Ed. Fondazione Banca Popolare di Verona. Verona: 32-37.

BONELLI M., MANENTI R., SCACCINI D., 2017. Mountain protected areas as refuges for threatened freshwater species: the detrimental effect of the direct introduction of alien species. *Eco. mont.* 9 (2): 23-29.

BRUGNOLI A., 2018. Verona illustrata a tavola, agricoltura, alimentazione e cucina in una città e nel suo territorio. Gianni Bussinelli Editore. Verona: 253 pp.

BRUNO M.C., ENDRIZZI S., GANDOLFI A., HAUFFE C.H., 2018. Piano di gestione del Gambero di fiume in Trentino. Trento: 103 pp.

CAODURO G., 2020. Una biodiversità Soave. In: AA.VV., 2020. Soave terroir. Le 33 unità geografiche aggiuntive del Soave. Ed. Fondazione Banca Popolare di Verona. Verona: 118-121.

CASSOL M., CANEVE L., BOZ B., 2018. Note preliminari sulla distribuzione di *Austropotamobius pallipes complex* in Provincia di Belluno. *Frammenti. Conoscere e tutelare la natura bellunese*, 8: 53-60.

CONFORTINI I., NATALI M., 1995. Presenza del gambero americano *Orconectes limosus* (Rafinesque, 1817), in alcuni corsi d'acqua della pianura veronese. *Ann. Mus. Civ. Rovereto, Sez.: Arch., St., Sc. Nat.*, 10: 399-404.

CONFORTINI I., 1994 (inedito). Progetto di recupero delle popolazioni di gambero di fiume *Austraotamobius pallipes italicus* (Faxon, 1984), della fascia montana, submontana e collinare della Provincia di Verona: 12 pp.

CONFORTINI I., 1992. Ricerca relativa all'ittiofauna dei corsi d'acqua. In: AA.VV., Carta Ittica dei corsi d'acqua della Provincia di Verona. Relazione tecnica: 875 pp.

FAVARO L., TIRELLI T., PESSANI D., 2010. The role of water chemistry in the distribution of *Austropotamobius pallipes* (Crustacea Decapoda Astacidae) in Piedmont (Italy). *Comptes Rendus Biologies*, 333: 68-75.

FÜREDER L., GMERARDI F., HOLDICM D., REYNOLDS J., SIBLEY P., SOUTY-GROSSET C., 2010. *Austropotamobius pallipes*. The IUCN Red List of Threatened Species 2010: e. T2430A9438817.

HOLDICH D.M., REYNOLDS J.D., SOUTHY-GROSSET C., SIBLEY P.J., 2009. A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Know. Managt. Aquat. Ecosyst*, 11: 394-395.

GHIA D., FEA G., MARRONE M., PICCOLI F., LANCIANI G., PAGLIANI T., FRACASSI G., 2014. Action plan per la conservazione di *Austropotamobius pallipes* in Italia. Pubblicazione realizzata nell'ambito del progetto LIFE08 NAT/IT/000352 - CRAINat con il contributo finanziario del programma "LIFE Natura e Biodiversita" della Commissione Europea.

LONGO L., MAGAGNA M., 1992. L'avifauna dei torrenti alpini e prealpini della Lessinia e del Monte Baldo. *Quaderni, La Lessinia. Ieri, Oggi, Domani*, 1: 260 pp.

MANENTI R., BONELLI M., SCACCINI D., BINDA A., ZUGNONI A., 2014. *Austropotamobius pallipes* reduction vs. *Procambarus clarkii* spreading: Management implications. *Journal for Nature Conservation*, 22: 586-591.

MANENTI R., GHIA D., FEA G., GENTILE F.F., PADOA-SCHIOPPA E., CANEDOLI C., 2019. Causes and consequences of crayfish extinction: Stream connectivity, habitat changes, alien species and ecosystem services. *Freshwater Biology*, 2: 1-10.

MARTINATI P., 1861. Nota sulla malattia dei gamberi, che ammorbò le acque del veronese nel 1861. *Memorie dell'Accademia d'Agricoltura Commercio ed Arti*, 41: 215-223.

MAZZONI D., GHERARDI F., FERRARINI P., 2004. Guida al riconoscimento dei gamberi d'acqua dolce. Bologna: 34 pp.

MORPURGO M., AQUILONI L., BERTOCCHI S., BRUSCONI S., TRICARICO E., GHERARDI F., 2010. Distribuzione dei gamberi d'acqua dolce in Italia. *Studi Trentini Scienze Naturali*, 87: 125-132.

OPPI E., 1986. Note sui danni provocati alla fauna ittica dalla siccità del 1985. *Quaderni*, *La Lessinia. Ieri, Oggi, Domani*, 1-2: 188 pp.

SALIN F., D'ALPAOS A., CARNIELLO L., ZAMPIERI D., ANTI U., 2014. Tesi di laurea magistrale in geologia e geologia tecnica sulla mitigazione della pericolosità idraulica del torrente Alpone: analisi degli effetti di una cassa di laminazione in località Brognoligo-Costalunga. Dipartimento di Geoscienze, Università di Padova.

SAMBUGARO A., FONTANA A., MOZZI P., 2014. Tesi di laurea magistrale in geologia e geologia tecnica analisi geomorfologica del sottosuolo del tratto terminale delle valli Chiampo-Agno, Alpone e Tramigna (Monti Lessini orientali). Dipartimento di Geoscienze, Università di Padova.

SAURO U.,2018. Lessinia, Cierre Edizioni, Sommacampagna: 280 pp.

SCALICI M., ROVELLI V., ZAPPAROLI M., BOLOGNA M.A., 2016. *Austropotamobius pallipes* (Lereboulet, 1858) *sensu lato* (Gambero di fiume) *A. torrentium* (Shranck,1803). In: Stoch F., Genovesi P. (Editors). Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/ CEE) in Italia: specie animali. ISPRA, Serie Manuali e linee guida: 26-27.

SCOVACRICCHI T., ALFARÈ L., 2016. Biodiversità - Specie - Invasioni biologiche. In: AA.VV. Fauna aliena ed invasiva in Veneto: problemi e proposte di gestione. *Veneto Tendenze* 2/2016, Quaderno di documentazione del Consiglio Regionale del Veneto.

SORMANI MORETTI L., 1903. La Provincia di Verona. *Monografia Statistica, Economica, Amministrativa*, 1: 602 pp.

SPAIRANI M., BERNINI F., NARDI P.A., FEA G., GHIA D., 2005. Primi risultati sulla distribuzione del gambero d'acqua dolce nell'Oltrepò pavese (Italia nord-occidentale). Quaderni 2005. Dipartimento di Biologia Animale Università degli Studi di Pavia: 22-32.

STOCH F., 2014. Decapodi. In: Genovesi P., Angelini P., Bianchi E., Dupré E., Ercole S., Giacanelli V., Ronchi F., Stoch F., 2014. Specie e habitat di interesse comunitario in Italia: distribuzione, stato di conservazione e trend. ISPRA, Serie Rapporti, 194/2014.

VALERINI A., 1586. Le bellezze di Verona: nuovo ragionamento, nel quale con brevità si tratta di tutte le cose notabili della città. Verona: 106 pp.

ZANETTI M., 2012. Il Progetto Rarity, LIFE10 NAT/IT/000239. In: AA.VV. Didattica per gli operatori. Pubblicazione realizzata con il contributo finanziario della CE, nell'ambito del Progetto Rarity, LIFE10 NAT/IT/000239, editing testi Tiziano Scovacricchi: 88 pp.

ZANINI D., 1992. Il gambero di fiume (*Austropotamobius pallipes fulcisianus*) nella regione benacese. In AA.VV. Il Garda l'ambiente, l'uomo. Cierre Ed., 8: 25-58.

WWF VERONESE, 2020. Guida al Parco Naturale della Lessinia. Sommacampagna (VR), Cierre Grafica: 143 pp.

Nuovi dati di distribuzione di *Derephysia sinuatocollis* Puton, 1879 per il Centro e Nord Italia (Hemiptera, Heteroptera, Tingidae)

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ABSTRACT

New data on the distribution of Derephysia sinuatocollis *Puton 1879 for Central and Northern Italy (Hemiptera, Heteroptera, Tingidae).*
New records on the distribution of Derephysia sinuatocollis *Puton for Northern and Central Italy are reported. The association with the host plant* Clematis vitalba *is confirmed. Targeted searches on this plant could extend the known areal of the species, considered rare until now.*
Key words: Derephysia sinuatocollis*,* Clematis vitalba*, leaves, bark, distribution, Lombardy, Piedmont, Tuscany, Italy.*

RIASSUNTO

Vengono pubblicati dati inediti sulla distribuzione di *Derephysia sinuatocollis* Puton per il Nord e Centro Italia. Viene confermata l'associazione con la pianta ospite *Clematis vitalba*. Ricerche specifiche su questa essenza potrebbero estendere l'areale di distribuzione noto di questa specie, considerata sinora rara.
Parole chiave: *Derephysia sinuatocollis, Clematis vitalba,* foglie, cortecce, distribuzione, Lombardia, Piemonte, Toscana, Italia.

INTRODUZIONE

Il genere *Derephysia* Spinola conta 12 specie, tutte della regione Paleartica tranne una sola della regione indo-malese (Péricart, 1983). La fauna mediterranea conta 7 specie conosciute. *Derephysia sinuatocollis* ha distribuzione Sud-europea ed è normalmente ritenuta specie molto rara. Allo stato attuale risulta segnalata in alcune località di Belgio (Baugné *et al*., 2002), Francia (Péricart, 1983; Streito, 2002), Lussemburgo (Schneider & Christian, 2013), Germania (Simon, 2003), Olanda (Aukema *et al*., 2005), Austria (Rabitsch, 2016), Macedonia (Göllner-Scheiding, 1978), Slovenia (Gogala, 2004), Bulgaria (Pericart & Golub, 1996) e Svizzera-Canton Ticino, Monte Generoso (Göllner-Scheiding *et al*., 1992), mentre per la Spagna, benché si ritenga che sia possibile la presenza nel Nord, i vecchi dati finora noti di Chicote (1880) relativi ai Pirenei non sono da ritenere sicuri (Baena & Torres, 2009). Per l'Italia c'erano soltanto un dato dell'Abruzzo-Riserva Naturale Sorgenti del Pescara (Carapezza *et al*., 1995), un vecchio dato della Liguria – Genova, loc. Casella – della prima metà del secolo scorso, di Mancini (Servadei, 1967; Péricart, 1983) e un dato del Veneto-Colli Berici, Brendola (Tescari, 1999) che era sinora il più settentrionale. I dati sono riportati anche nella Chekmap delle specie della Fauna d'Italia (Carapezza & Faraci, 2005).

DATI INEDITI

Lombardia (SO), loc. Triangia, 800 m c.ca, lungo il sentiero nei dintorni del lago omonimo, 18.VII.2019, 1 ex., sfalcio su *Clematis vitalba,* M. Salvetti leg.; **Toscana** (FI), dint. Marradi: loc. Albero m 500, sfalcio su *Clematis vitalba*, 25.VII.1991, 1 ex., F. Poggi leg.; **Toscana** (FI), dint. Marradi: loc. Cortecce m 950, sfalcio su *Clematis vitalba,* 4.VIII.1995, 1 ex., F. Poggi leg.

Dati online: **Piemonte** – Forum Natura Mediterraneo, Avigliana (TO) Monte Cuneo, 15.VII.2016, foto di Vincenzo Di Taddeo (Forum Natura Mediterraneo).

Fig. 1 – *Derephysia sinuatocollis*, esemplare di Marradi (foto Francesco Poggi)

Discussione

D. sinuatocollis è specie inconfondibile dal punto di vista morfologico (Pericart, 1978), per la forma stretta e sinuosa delle espansioni laterali del pronoto, con gli angoli anteriori che vanno a stringersi e allungarsi notevolmente lateralmente al capo (Figura 1). Di questa specie si ritenevano sconosciute le piante ospiti (Péricart, 1983) prima dei lavori di Dauphin (1986), che è il primo a citare *Clematis vitalba*, dove l'insetto si trova prevalentemente nelle scanalature dei fusti, specialmente laddove la parte corticale si sfalda, ma raramente sul fogliame. L'Autore afferma che la specie compie una generazione all'anno con deposizione delle uova nei fusti delle *Clematis* in autunno e la comparsa delle prime neanidi in aprile. L'associazione con *Clematis vitalba* è stata poi confermata anche da Dorow *et al.* (2004) e Gogala (2004). In seguito anche Baena & Torres (2009) confermano l'associazione con questa pianta ospite, fornendo anche nuovi dati per la Francia e la Spagna.

Per quanto riguarda l'habitat, secondo Dorow *et al.* (2004), in Germania si trova in numerose tipologie di ambienti contrassegnati da differenti categorie fitosociologiche: vigneti, zone ruderali, boschi di querce e aceri (*Aceri monspessulani, Quercetum petraeae*). In Macedonia secondo Göllner-Scheiding (1978) è stata trovata in una catena montuosa fino a un massimo di circa 1.000 m, in versanti con bosco misto di querce, ma anche in ambienti con prati poveri con singoli faggi, querce e cespugli di ginepro.

I dati inediti confermano l'associazione con *Clematis vitalba*, essendo stati trovati tutti gli esemplari sulla specie citata, e consentono di segnalare *D. sinuatocollis* come nuova per il Piemonte, la Lombardia e la Toscana, estendendo significativamente l'areale di distribuzione nel Centro-Nord Italia.

Pertanto, come già sostengono Dorow *et al.* (2004), molto probabilmente la specie è più diffusa di quanto non sembri e le lacune nella distribuzione sono dovute a carenza di ricerche mirate sulla pianta ospite, in particolare sulle cortecce; ciò ha portato gli specialisti a ritenerla molto rara; l'argomento è dunque meritevole di attenzione e di ulteriori approfondimenti effettuando indagini mirate, in biotopi diversi, ponendo particolare attenzione sia sulla parte erbacea che sulle cortecce dei fusti di *Clematis*: ne potrebbero scaturire ulteriori interessanti scoperte al fine di ampliare notevolmente l'areale di distribuzione noto di questa specie in Italia e non solo.

Ringraziamenti

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Bibliografia

AUKEMA B., BOS F., HERMES D. & ZEINSTRA PH., 2005. Nieuwe en interessante Nederlandse wantsen II, met een geactualiseerde naamlijst (Hemiptera: Heteroptera). *Nederlandse Faunistische Mededelingen*, 23: 37-76.

BAENA M. & TORRES J.L., 2009. Una especie nueva de Derephysia de Andalucía (España): *Derephysia (Derephysia) josepha* n. sp. (Heteroptera: Tingidae). *Boletín de la Sociedad Entomológica Aragonesa (SEA),* 45: 97-100.

Fig. 2 – *Derephysia sinuatocollis*, esemplare di Avigliana, Monte Cuneo (foto Francesco Di Taddeo)

BAUGNÉE J.-Y., MINET G. & CONSTAN TJ., 2002. Additions et corrections à la faune des Hétéroptères de Belgique (Hemiptera: Heteroptera). *Bulletin de la Société Royale Belge d'Entomologie*, 138: 52-58.

CARAPEZZA A., DI MARCO C., OSELLA G., 1995. Ricerca sulla fauna della Riserva Naturale guidata "Sorgenti del Pescara". II: Hemiptera Heteroptera: ecologia e biodiversità. *Bollettino del Museo regionale di Scienze Naturali di Torino, Torino,* 13 (1): 123-220

CARAPEZZA A., FARACI F., 2005. Insecta Heteroptera Leptopodidae, Saldidae, Miridae (partim), Tingidae. In: Ruffo S. & Stoch F. (Editors), Cheklist e distribuzione della fauna Italiana. Specie terrestri e delle acque interne. *Memorie del Museo Civico di Storia Naturale di Verona*. Ministero dell'Ambiente e della Tutela del Territorio: 307 pp. (con CD).

CHICOTE C., 1880. Adiciones a la enumeración de los Hemípteros observados en España y Portugal. Anales de la Sociedad Española de Historia Natural, 9: 185-203.

DAUPHIN P., 1986. Sur la biologie et la repartition de *Derephysia sinuatocollis* Puton (Het. Tingidae). *Bulletin de la Société linnéenne de Bordeaux,* 14 (4): 177-182.

DOROW W.H.O., VOIGT K., FLECHTNER G., 2004. Erstnachweis von *Derephysia sinuatocollis* Puton, 1879 (Heteroptera: Tingidae) in Hessen. *Heteropteron,* 19: 15-17.

GOGALA A., 2004. Heteroptera of Slovenia, II: Cimicomorpha 1. *Annales. Series historia naturalis*, 14 (2): 237-258.

GÖLLNER-SCHEIDING U., 1978. Beitrag zur Kenntnis der Heteropterenfauna Mazedoniens. *Acta Musei Macedonici Scientiarum Naturalium,* 15: 145-150.

GÖLLNER-SCHEIDING U. & REZBANYAI-RESER L., 1992. Zur Wanzenfauna des Monte Generoso, Kanton Tessin, Südschweiz (Heteroptera). *Entomologische Berichte Luzern*, 28: 15-35.

PÉRICART J., 1978. Révision systématique des Tingidae Ouest-paléarctiques. 3. - Subdivision du genre *Derephysia* et revue critique des espèces (Hemiptera). *Annales de la Société Entomologique de France* (N.S.), 14: 87-94.

PÉRICART J., 1983. Hémiptères Tingidae euro-méditerranéens. *Faune de France*, 69: 618 pp.

PÉRICART J. & GOLUB V.B., 1996. Family Tingidae Laporte, 1832. In Aukema B. & Rieger C. (Editors). Catalogue of the Heteroptera of the Palaearctic Region. The Netherlands Entomological Society, Amsterdam, 2: 3-78.

RABITSCH W., 2016. Notizen zur Wanzenfauna (Hemiptera: Heteroptera) von Wien, mit fünf Neufunden für Österreich. *Beiträge zur Entomofaunistik*, 17: 39-54.

SCHNEIDER N. & CHRISTIAN S., 2013. Découverte de *Corythucha ciliata* (Say, 1832) et de *Derephysia sinuatocollis* Puton, 1879 au Luxembourg et autres observations dignes d'intérêt (Insecta, Hemiptera, Heteroptera). *Bulletin de la Société des naturalistes luxembourgeois*, 114: 105-109.

SERVADEI A., 1967. Fauna d'Italia. Rhynchota (Heteroptera, Homoptera Auchenorrhyncha) Calderini, Bologna, IX, 851 pp.

SIMON H., 2003. Erste Nachweise der Netzwanze *Derephysia sinuatocollis* Puton, 1879 (Heteroptera, Tingidae) in Deutschland. *Fauna Flora Rheinland-Pfalz,* 10: 285-288.

STREITO J.C., 2002. Notes sur quelques Tingidae nouveaux ou intéressants pour l'Alsace et la Lorraine. *Bulletin de la Societé Entomologique de Mulhouse*, 58 (1): 1-3.

TESCARI G., 1999. Segnalazioni faunistiche italiane n. 369. *Bollettino della Società Entomologica Italiana,* 131: 259.

SITOGRAFIA

Forum Natura Mediterraneo: www.naturamediterraneo.com/forum/topic.asp?TOPIC_ID=295586

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Bollettino del Museo Civico di Storia Naturale di Verona, 45, 2021 Botanica Zoologia: 25-28

Alcuni notevoli casi di ginandromorfismo e altre teratologie nei Malachiidi

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Abstract

Some notable cases of gynandromorphism and other teratologies in Malachiids
Three interesting cases of gynandromorphism are reported in specimens of Malachius (Malachius) bipustulatus *(Linnaeus, 1758),* Ceratistes dilaticornis *(Germar, 1824),* Colotes (Colotes) maculatus *(Laporte de Castelnau, 1838). Some other teratologies involving different anatomical regions are also reported.*

Key words: *Teratology, Gynandromorphism, Malachiidae.*

Riassunto

Si segnalano tre interessanti casi di ginandromorfismo in esemplari di *Malachius (Malachius) bipustulatus* (Linnaeus, 1758), *Ceratistes dilaticornis* (Germar, 1824), *Colotes (Colotes) maculatus* (Laporte de Castelnau, 1838), oltre ad altre teratologie interessanti diverse regioni anatomiche.

Parole chiave: Teratologia, ginandromorfismo, Malachiidae.

Lo studio nell'arco di oltre un ventennio di diverse migliaia di esemplari della fauna italiana ed europea di Malachiidae mi ha consentito di notare un numero sorprendentemente alto di esemplari affetti da varie forme di teratologia. Tali forme sono riscontrabili in tutte le regioni anatomiche ma, sia pure con frequenza variabile da specie a specie, sembrano interessare prevalentemente le antenne e le elitre e solo marginalmente zampe o altre appendici. Particolarmente frequenti risultano essere le forme soggette da fusioni o atrofie di alcuni antennomeri, displasia elitrale e emibrachelitria.

Sebbene molti casi di teratologia nei Malachiidi siano già noti (Evers, 1968; Sieber & Klausnitzer, 1973; Kaplan, 1976; Pasqual, 1991a), di particolare interesse appaiono tre esemplari da me studiati affetti da ginandromorfismo. Il primo caso riguarda un esemplare di *Malachius (Malachius) bipustulatus* (Linnaeus, 1758) affetto da ginandromorfismo interessante l'intero esemplare con parte destra a fenotipo maschile e la restante parte sinistra a fenotipo femminile, fronte e antenne comprese. Il secondo caso riguarda un esemplare di *Ceratistes dilaticornis* (Germar, 1824) in cui il suddetto fenomeno interessa soltanto le antenne (destra femminile, sinistra maschile interessata inoltre da fusioni di alcuni gruppi di antennomeri). Il terzo caso in questione è relativo a un esemplare di *Colotes (Colotes) maculatus* (Laporte de Castelnau, 1838) in cui sono gli articoli dei palpi mascellari a essere affetti da ginandromorfismo. Altre forme di teratologia riscontrate negli esemplari da me studiati riguardano: la fusione di alcuni antennomeri: *Clanoptilus* (*Clanoptilus) arnaizi* Pardo Alcaide, 1966, *Malachius (Malachius) australis* Mulsant & Rey, 1867; l'atrofia o riduzione nel numero di alcuni antennomeri: *Clanoptilus (Hypoptilus) sardous* Erichson, 1840, *Malachius (Malachius) australis* Mulsant & Rey, 1867, *Clanoptilus (Clanoptilus) spinipennis* Germar, 1824; forme varie di displasia elitrale e dell'ala metatoracica: *Cordylepherus viridis* Fabricius, 1787, *Sphinginus coarctatus* (Erichson, 1840), *Charopus rotundatus* (Erichson, 1840), *Charopus apicalis* (Erichson, 1840), *Charopus concolor* (Fabricius, 1801); anomalia delle zampe: *Clanoptilus (Clanoptilus) rufus* (A.G. Olivier, 1790). Tutti gli esemplari oggetto del presente studio sono conservati presso la mia collezione personale.

ESEMPLARI AFFETTI DA GINANDROMORFISMO

1 *Malachius (Malachius) bipustulatus* (Linnaeus, 1758)

M. Cagno, m 1395, Borbona (Rieti)
15.VI.2007

Capo esattamente diviso a metà. Parte sinistra a fenotipo femminile con fronte davanti all'inserzione delle antenne caratterizzata da un solco trasverso semplice. Antenna sinistra con secondo articolo molto più largo che lungo, molto più stretto del terzo, terzo e quarto moderatamente ingrossati e quadrangolari, i rimanenti moderatamente dentati. Parte destra a fenotipo maschile con fronte davanti alle antenne recante un solco trasverso molto profondo con la presenza di una corta ma pronunciata carena longitudinale recante alcune lunghe setole al margine anteriore. Antenna destra con primo articolo corto, secondo corto e molto allungato in avanti, terzo triangolare e dentiforme, quarto più lungo e ricurvo moderatamente securiforme, i rimanenti lievemente dentati a sega (Figura 1).

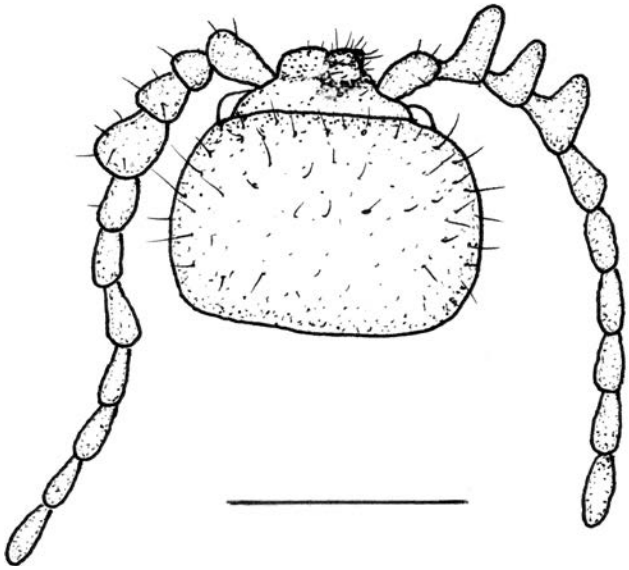

Fig. 1 – *Malachius (Malachius) bipustulatus* (Linnaeus, 1758). Pronoto e capo con antenne interessato da ginandromorfismo. Scala 1 mm
Malachius (Malachius) bipustulatus *(Linnaeus, 1758). Pronotum and head with antennae affected by gynandromorphism. Scale bar 1 mm*

2 *Ceratistes dilaticornis* (Germar, 1824)

Epiro, M. Pindo, m 1500, Joannina, Grecia
26.VI.2002

Antenna destra a fenotipo femminile con primo articolo leggermente a clava, secondo corto, terzo triangolare, quarto moderatamente dentiforme, quinto articolo molto lungo della lunghezza dei due seguenti presi assieme, i rimanenti lievemente dentati a sega. Antenna sinistra a fenotipo maschile ma interessata da fusione di alcuni antennomeri. Primo articolo leggermente clavato, secondo corto, terzo, quarto e quinto gradatamente ingrossati a sega, in particolare il quinto, e fusi tra loro dorsalmente in modo completo e ventralmente solo parzialmente da consentirne ancora una separazione morfologica. Sesto, settimo e ottavo articolo irregolarmente ingrossati e fusi tra loro, nono articolo vestigiale, i rimanenti mancanti (Figura 2).

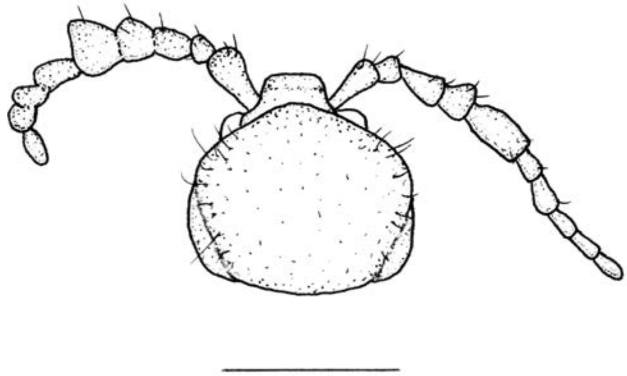

Fig. 2 – *Ceratistes dilaticornis* (Germar, 1824). Pronoto e capo con antenne interessate da ginandromorfismo e parziale fusione di alcuni antennomeri. Scala 1 mm
Ceratistes dilaticornis *(Germar, 1824). Pronotum and head with antennae affected by gynandromorphism and partial fusion of some antennomers. Scale bar 1 mm*

3 *Colotes (Colotes) maculatus* (Laporte de Castelnau, 1838)

Aspromonte, Platì, m 600, (Reggio di Calabria);
23.VI.1993

Palpo mascellare destro a fenotipo maschile, con secondo e terzo articolo molto grossi e quadrangolari, molto più grossi del primo lievemente claviforme. Palpo mascellare sinistro a fenotipo femminile con primi due articoli corti e terzo articolo molto grande e securiforme (Figura 3). Le restanti regioni anatomiche non presentano dimorfismo sessuale; le ali metatoraciche, normalmente affette da polimorfismo nell'ambito della specie in questione (Pasqual, 1991b) risultano solo parzialmente interessate da lieve brachitterismo.

ESEMPLARI AFFETTI DA FORME DI TERATOLOGIA RIGUARDANTI DIVERSE REGIONI ANATOMICHE

Antenne

Malachius (Malachius) australis
Mulsant & Rey, 1867, femmina
Liguria, Savona
15.VII.1995

Primo articolo dell'antenna destra di forma anomala schiacciato longitudinalmente in parte con presenza di una fossetta lungo il margine distale.

Clanoptilus (Clanoptilus) arnaizi
Pardo Alcaide, 1966, maschio
Piemonte, Val Maira, Prazzo (Cuneo)
24.V.2000

Primi tre articoli dell'antenna destra di foggia normale, 4° e 5° notevolmente ingrossati e parzialmente fusi tra loro, 6°, 7° e 8° completamente fusi tra loro con l'estremità del 7° e l'intero 8° ingrossati verso il margine distale; 9° e 10° filiformi fusi tra loro, 11° molto corto triangolare.

Clanoptilus (Hypoptilus) sardous
Erichson, 1840, femmina
Sardegna, Golfo Aranci (Sassari)
2.V.1995

Antenna sinistra esile di soli 9 antennomeri.

Clanoptilus (Clanoptilus) spinipennis
Germar, 1824, femmina
Grecia, Messinia
5.V.2004

8° articolo dell'antenna destra notevolmente ingrossato, più grande di tutti gli altri, irregolarmente allargato e triangolare.

Malachius (Malachius) australis
Mulsant & Rey, 1867, maschio
Piemonte, Val Maira, Prazzo (Cuneo)
23.V.2000

Primi 4 articoli dell'antenna destra di foggia normale, 5° molto più corto e ingrossato, 6°-7° molto corti, ingrossati e compressi in senso longitudinale, 8° irregolarmente globoso, 9° molto piccolo, corto e appuntito. 10° e 11° mancanti.

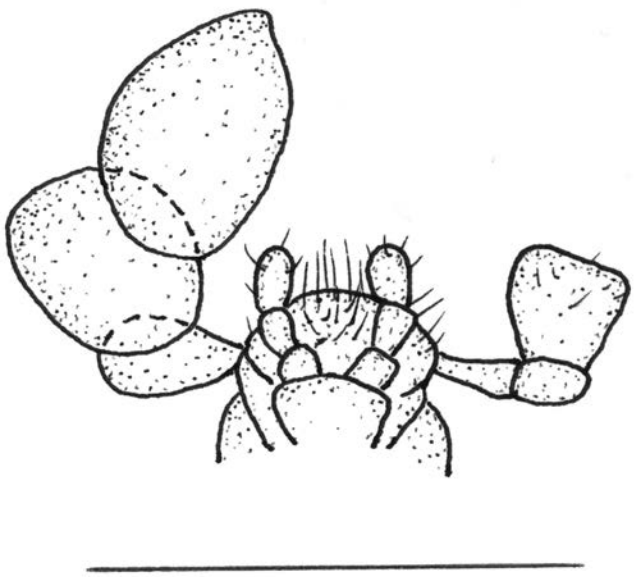

Fig. 3 – *Colotes (Colotes) maculatus* (Laporte de Castelnau, 1838). Labbro inferiore con palpi labiali interessati da ginandromorfismo. Visione ventrale. Scala 0.5 mm
Colotes (Colotes) maculatus *(Laporte de Castelnau, 1838). Lower lip with labial palps affected by gynandromorphism. Ventral vision. Scale bar 0.5 mm*

Malachius (Malachius) australis
Mulsant & Rey, 1867, femmina
Sicilia, Mistretta (Messina)
15.VI.1993

Antenna destra con primi 2 articoli normali, 3° di forma notevolmente anomala, romboidale, 4° e 5° ingrossati e parzialmente fusi tra loro lungo il margine dorsale, 6° di foggia più o meno normale ma più allungato, 7° allargato triangolare, 8° piccolo, breve e appuntito, gli altri mancanti.

Zampe

Clanoptilus (Clanoptilus) rufus
(A.G. Olivier, 1790), maschio
Toscana, Scarlino (Grosseto)
2.V.1997

Zampa media sinistra anomala con femore molto corto, circa un terzo del normale, tibia cortissima, ingrossata e fortemente arcuata, tarso costituito da un unico articolo lungo quasi quanto quelli normali, privo di unghie.

Elitre

Cordylepherus viridis
Fabricius, 1787, maschio
Liguria, Varese Ligure (La Spezia)
22.V.1998

Elitre ai 2/3 della loro lunghezza schiacciate trasversalmente con la restante parte accartocciata verso l'alto e verso il margine esterno.

Sphinginus coarctatus
Erichson, 1840, femmina
Puglia, Martina Franca (Taranto)
29.IV.1990

Elitre vestigiali molto sottili e parzialmente trasparenti prive completamente di chetotassi, convesse lungo i margini laterali con apice accartocciato. Ali metatoraciche normali.

Charopus cf. *rotundatus*
(Erichson, 1840), femmina
Sardegna, Lula (Nuoro)
5.V.1995

Elitra destra molto corta, e accartocciata subito oltre il callo omerale, molto ristretta e terminante con una punta acuminata. Elitra sinistra corta, ristretta, con l'estremità schiacciata e leggermente piegata verso l'esterno.

Charopus cf. *apicalis*
(Erichson, 1840), femmina
Sicilia, Isnello (Palermo)
9.VI.1991

Elitra sinistra vestigiale, molto stretta e corta, irregolarmente accartocciata con l'estremità triangolare bruscamente ripiegata verso l'alto. Elitra destra di dimensioni normali, ma parzialmente schiacciata trasversalmente.

Ala metatoracica

Charopus concolor
(Fabricius, 1801), maschio
Trentino Alto Adige, Brione, M. Brione (Trento)
6.V.1994

Ala destra di conformazione normale nella sua metà prossimale; parte distale priva di nervature e visibilmente rigonfia a palloncino, con lamina alare dorsale nettamente staccata da quella inferiore, entrambe recanti finissima chetotassi. Ala sinistra normale.

BIBLIOGRAFIA

EVERS A.M.J., 1968. Anomalien bei Malachiidae (Col.) (37 Beitrag zur Kenntnis der Malachiidae). *Decheniana*, 120: 65-80, 12 Figg.

KAPLAN A.I., 1976. Antennal deformities in *Collops* (Coleoptera Malachiidae). *Pan Pacific Entomology*, 52 (1): 92.

PASQUAL C., 1991a. Su alcuni esemplari teratologici del genere *Malachius* Fabricius 1775. *Bollettino della Società Entomologica Italiana, Genova*, 123 (2): 97-99.

PASQUAL C., 1991b. Aspetti adattativi del dimorfismo sessuale dell'ala metatoracica nei Coleotteri Malachiidi della fauna italiana. *Atti XVI Congresso nazionale italiano di Entomologia, Bari-Martina Franca (TA)*, 23-28/09/1991: 297-301.

SIEBER M. & KLAUSNITZER B., 1973. Zwei Missbildungen bei Kafer (Carabidae, Malachiidae). *Ent. Nach. Dresden*, 15 (9-10): 109-111, 2 Figg.

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A gynandromorph of ant *Tetramorium simillimum* (Smith, F., 1851) from Tahiti (Polynesia) (Hymenoptera Formicidae)

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ABSTRACT

The description of a gynandromorph of the ant Tetramorium simillimum *(Smith F., 1851) from Tahiti is here provided. The list of South Pacific ant specimens stored in the ant collection of the Natural History Museum from Verona is also provided.*

Key words: *Ants, gynandromorphy, islands, South Pacific.*

INTRODUCTION

In the Natural History Museum of Verona, the majority of ants are dry stored in the «general» and in the «Baroni Urbani» collections, but the available material includes also specimens preserved in 70° alcohol. Recently I studied an interesting small lot of South Pacific ants (especially Polynesian), preserved in liquid, and occasionally collected by arachnologist Paolo Marcello Brignoli and collaborators during their researches on the South East Asian spider fauna, in the year 1982. I have identified 28 species (see list in appendix), mostly common or widespread, and therefore of little interest. An exception concerns a specimen of *Tetramorium simillimum* (Smith F., 1851), because it is a gynandromorph. This morphological condition shows both male and female tissues in the same individual. Such mosaics in the Hymenoptera are accidentally formed during the embryogenesis or fertilization or for loss of expression of the sex loci in some cells (Wiggleswort 1972; Jones and Philips 1985; Michez *et al.*, 2009; Yoshizawa *et al.*, 2009; Campos *et al.*, 2011; Yang and Abouheif, 2011). Gynandromorphy is present in various genera of Formicidae but of course is not frequent. In fact, it is known in just under fifty species (Skvarla *et al.*, 2015) belonging in almost all the subfamilies of ants but especially in the Formicinae and Myrmicinae.

In the genus *Tetramorium* Mayr, 1855 (Myrmicinae: Crematogastini) gynandromorphy is reported only in two pantropical tramp species. In *Tetramorium bicarinatun* (Nylander, 1846) by Wheeler (1924: 136, *as T. guineense* Fabricius) and in *T. simillimum* (Smith F., 1851) by Roger (1857: 15, as *Tetrogmus caldarius* Roger), Meinert (1861: 331, as *Myrmica caldaria* Roger), Santschi (1920: 176), and recently by Deyrup (2016) (but without description of the specimen).

The gynandromorph of *Tetramorium simillimum* from Polynesia here reported, looks like a winged gyne but with bilateral symmetry between female/male tissues in the head and mesonotum as highlighted in the description given below. Curiously, a second gynandromorph of this species was already reported from Polynesia: in fact the specimen described by Santschi (1920) is from Apia island (now Upolu island) (Samoa).

DESCRIPTION OF THE GYNADROMORPH

Tetramorium simillimum (Smith F., 1851)
(Figures 1-3)

Material: Polynesia Fr., Tahiti, Vaiufanza,7.IX.1982, leg. Brignoli & El Helou, 1 gynandromorph (Museum Verona).

TL 3.02 mm. In frontal view, the left side of head is female, with lateral contour normally convex and with 12-jointed left antenna. Left mandible female, large. Left compound eye female and normally developed (maximum diameter = 0.16 mm), well distant from the anterior margin of cheek (distance from eye to malar margin = 0.13 mm). The right side of head is male with less convex lateral contour and with posterior margin of head inclined. The right antenna is male with scape short followed by 9 flagellar segments. First fu-

Fig. 1 – Gynandromorph of *Tetramorium simillimum*: body in lateral view

Fig. 2 – Gynandromorph of *Tetramorium simillimum*: head in face view

nicular segment (pedicel excluded) typically very long as in all males of the genus *Tetramorium*. Right mandible male. Right compound eye male and large (maximum diameter = 0.22 mm) and placed very near to anterior margin of cheek (distance from eye to malar margin = 0.04 mm). Three ocelli are present but the one on the left is less developed (as in the normal gyne) while the remaining two are larger as in the males. Mesosoma female, normally developed but with mesoscutum in dorsal view with left side female and surface sculpted by longitudinal carinulae, while the right side is male with surface smooth and with presence of one well-marked notaulus. Wing normal developed. Metasoma female with normal petiole, postpetiole and gaster.

The anomalous structure of head, here described, closely resemble that of the gynandromorph (male-worker combinations) described and figured by Roger (1857, tab. I: sub *Tetrogmus caldarius* = *Tetramorium simillimum*) and refigured by Wheeler (1903: 668) but also with the head described by Santschi (1920). It should be noted that the Santschi's specimen (having gyne/male tissues) differs from the gynandromorph here described, for the former's normal gyne mesosoma and male gaster.

Fig. 3 – Gynandromorph of *Tetramorium simillimum*: mesosoma in dorsal view

APPENDIX

Besides the specimen of *Tetramorium simillimum*, during the researches of Brignoli and collaborators in the South Pacific Islands the following ant species were collected (now all stored in the dry «General Collection» of the Natural History Museum of Verona).

Anoplolepis gracilipes (Smith F., 1857)
Moorea, Titroa, 10.XI.1982, leg. Missi, 1 worker. Samoa, Tutuila Mapusaga, 1.IX.1982, leg. Missi 1 worker. Western Samoa, Upolu, Latofaga, 28-30.X.1982, leg. Brignoli, 2 workers. Tahiti, Mahina, 5.XI.1982, leg. Cottarelli, 1 worker. Vanuatu, Efate, Rentabao City, 22.X.1982, leg. El Helou, 2 workers. Vanuatu, Efate, Ulei, 23.X.1982, leg. El Helou 1 worker.

Brachymyrmex cordemoyi Forel, 1895
Western Samoa, Upolu, O Le Popu, 28.X.1982, leg. Brignoli, 1 worker.

Cardiocondyla minutior Forel, 1899
Tahiti, Vaiufanza, 7.IX.1982, leg. Brignoli & El Helou, 1 worker.

Europalothryx cf. *procera* (Emery, 1897)
Western Samoa, Upolu, Latofaga, 20-30.X.1982, leg. Brignoli, 1 male.

Colobopsis polynesica (Emery, 1896)
Fiji, Viti Levu, Nausori, 14.X.1982, leg. Brignoli, 1 worker.

Colobopsis sp.
Vanuatu, Efate, Rentabao City, 22.X.1982, Brignoli, 1 worker.

Camponotus gambeyi Emery, 1883
New Caledony Mountains Koghis (Noumea dint.), 21.X.1982, leg. Missi & El Helou, 3 workers.

Camponotus sp. nov.?
New Caledony, Mountains Koghis (Noumea dint.), 21.X.1982, leg. Missi & El Helou, 1 worker.

Campontus sp.
Salomon, Guadalcanal, Mt. Austin, 7.II.1982, leg. El Helou, 1 worker.

Hypoponera sp.
Fiji, Viti Levu, Noshi dint., 25.X.1982, leg. Brignoli, 1 gyne.

Monomorium floricola (Jerdon, 1851)
Moorea, Titiroa 10.XI.1982, leg. Missi, 1 worker.

Nylanderia vaga (Forel, 1901)
Salomon, Guadalcanal, Mt. Austin, 7.II.1982, leg. El Helou, 1 worker. Vanuatu, Efate, Rentabao City, 22.X.1982, leg. Brignoli, 1 worker.

Oecophylla smaragdina (Fabricius, 1775)
Salomon, Guadalcanal, Viari, 10.II.1982, leg. El Helou, 4 workers.

Odontomachus simillimus Smith, F. 1858
Salomon, Guadalcanal, Mt. Austin, 7.II.1982, leg. Brignoli, 1 worker. Samoa, Tutuila, Mapusaga, Feu, 1.IX.1982, leg. El Helou, 1 worker. Western Samoa, Upolu, O Le Popu, 28.X.1982, leg. Brignoli, 1 worker. Vanuatu, Efate, Rentabao City, 22.X.1982, leg. El Helou, 1 worker.

Pheidole fervens Smith F. 1858
Fiji, Viti Levu, Nausori, 27.X.1982, leg. Cottarelli, 1 worker, 1 soldier.

Pheidole megacephala (Fabricius, 1793)
Western Samoa, Upolu, Afiamalu, 20-30.X.1982, leg. Brignoli, 1 worker.

Pheidole sp. 1
Western Samoa, Upolu, O Le Popu, 26.X.1982, leg. Brignoli, 1 worker.

Pheidole sp. 2
Western Samoa, Upolu, Latofaga, 27.X.1982, leg. Missi, 1 worker.

Pheidole sp. 3
Western Samoa, Upolu, O Le Popu, 26.X.1982, leg. Brignoli, 1 worker.

Rogeria stigmatica Emery, 1897
Samoa, Tutuila, Mapusaga, 1.IX.1982, leg. Missi, 1 worker.

Solenopsis geminata (Fabricius, 1804)
Salomon, Guadalcanal, Mt. Austin, 7.II.1982, leg. El Helou, 1 worker.

Solenopsis sp.
Vanuatu. Efate, Ulei, 23.X.1982, leg. Missi, 6 workers.

Strumigenys godeffroyi Mayr, 1866

Fiji, Viti Levu, Nausori, 27.X.1982, leg. Cottarelli, 3 workers. Tahiti, Vaiufanza, 7.IX.1982, leg. Missi, 2 workers.

Strumigenys sp.

Fiji, Viti Levu, Nausori, 27.X.1982, leg. Cottarelli, 1 gyne.

Tapinoma melanocephalum (Fabricius, 1793)

Fiji, Viti Levu, Nausori, 27.X.1982, leg. Cottarelli, 1 worker; Vanuatu, Efate, Rentabao City, 22.X.1982, leg. Brignoli, 2 workers.

Tetramorium bicarinatum (Nylander, 1846)

Tahiti, Faravao, 5.XI.1982, leg. El Helou, 1 worker.

Tetramorium pacificum Mayr, 1870

Polynesia Franc., Foca, 6.XI.1982, leg. Brignoli & El Helou, 2 workers. Fiji, Viti Levu, Nausori, 27.X.1982, leg. Cottarelli, 1 worker. Tahiti, Vaiufanza, 7.IX.1982, leg. Missi, 1 worker. Vanuatu, Efate, Ulei, 23.X.1982, leg. Brignoli, 1 worker.

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REFERENCES

CAMPOS A.E.C., KATO L.M., ZARZUELA M.F.M., 2011. Occurrence of different gynandromorphs and ergatandromorphs in laboratory colonies of the urban ant *Monomorium floricola*. Journal of Insect Science, 11 (17): 1-10.

DEYRUP M.A., 2016. Ants of Florida: Identification and Natural History. *CRC Press*: 423 pp.

JONES S.R., PHILLIPS JR S.A., 1985. Gynandromorphism in the ant *Pheidole dentata* Mayr Hymenoptera: Formicidae). *Proceedings Entomological Society of Washington,* 87: 583-586.

MEINERT F., 1861. Bidrag til de danske Myrers Naturhistorie. *Kongelige Danske Videnskabernes Selskabs Skrifter*, (5) 5: 273-340.

MICHEZ D., RASMONT P., TERZO M., VEREECKEN N.J,. 2009. A synthesis of gynandromorphy among wild bees (Hymenoptera: Apoidea), with an annotated description of several new cases. *Annales de la Société Entomologique de France*, 45: 365-375.

ROGER J., 1857. Einiges über Ameisen. 2 Ein zwitter von *Tetrogmus caldarius. Berliner Entomologische Zeitschrift*, I: 10-20.

SANTSCHI F., 1920. Cinq nouvelles notes sur les fourmis. *Bulletin de la Société Vaudoise des Sciences Naturelle*, 53: 163-186.

SKVARLA M.J., DOWLING A.P.G., 2014. First report of gynandromorph in *Temnothorax curvispinosus* (Mayr, 1866) (Hymenoptera: Formicidae). *Proceedings Entomological Society of Washington*, 116 (3): 349-353.

WHEELER W.M., 1903. Some new gynandromorphous ants, with a review of the previously recorded cases. *Bulletin of the American Museum of Natural History*, 19: 653-683.

WHEELER W.M., 1924. A gynandromorphy of *Tetramorium guineense* Fabr. Psyche, 31 (Cambridge) (3-4): 136-137.

WIGGLESWORTH V.B., 1972. The principles of insect physiology. Seventh edition. Chapman and Hall, London: viii + 827 pp.

YANG A.S., Abouheif E., 2011. Gynandromorphs as indicators of modularity and evolvability in ants. *Journal of Experimental Zoology*. Part B *Molecular and Developmental Evolution*, 314: 1-6.

YOSHIZAWA J., MIMORI K., YAMAUCHI K., TSUCHIDA K., 2009. Sex mosaics in a male dimorphic ant *Cardiocondyla kagutsuchi*. *Naturwissenschaften*, 96: 49-55.

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Otolith mass asymmetry in *Acanthopagrus arabicus* Iwatsuki, 2013 collected from the Iraqi marine waters

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ABSTRACT

Otolith mass asymmetry may show some growth disorders in fish affected by environmental impacts. Mostly high-level otolith mass asymmetry can negatively upsetting fish life, consequently the assessment per species is very momentous. Saccular otolith mass asymmetry is investigated in the sparid fish species, Acanthopagrus arabicus *collected from Khor al-Zubair at the North-West region of the Arabian Gulf. This feature was calculated as the discrepancy between the weight of the right and left otoliths divided by mean otolith weight in the three sparid species examined. Conferring to the preceding instances attained on another symmetrical fish species, the absolute value of* x *in these species does not resolute by fish length and otolith growth ratio, while the absolute rate of otolith weight disparity is increased with the fish length. The estimate of* x *was between -0.2 and +0.2. Otolith mass asymmetry can show some growth anomaly of fish due to environmental impacts.*

Key words: *Otolith, Ecology, Asymmetry, Sparidae,* Acanthopagrus*, Arabian Gulf.*

INTRODUCTION

Among animals, fishes can be affected by unfavourable environmental factors more than any other groups because they are directly facing and become vulnerable to such impacts (Yedier *et al.*, 2018). In teleosts fish species, there are three sets of otolith inside their inner ear known as Asteriscus, lapillus, and Sagitta. The function of the otoliths in the fish body is imperative for the endure living of the fish and contains body balance, hearing, gravity sensation and linear acceleration in the species (Nolf, 1985; Poper and Lue, 2000). The otoliths are usually having bilateral symmetrical structure in the fish, but their weights are different between the left and right otolith, and this is what called otolith mass asymmetry.

The asymmetry in fish species is expected to express the growth disorders of fish owing to different type of impacts such as genetic or environmental stresses (Valentine *et al.*, 1973). Whatever the mass asymmetry is, increase or decrease, the result will affect negatively fish action, chiefly hearing and balance. Consequently, otolith mass asymmetry has been exploited as a bioindicator to check the health of the environment that the fish living in (Grønkjaer and Sand, 2003).

The sparid fish examined in the present study are amongst the significant commercial fish species along its geographical dispersal. It is marine species and often found in fresh and brackish waters. Individuals of the yellowfin seabream, *A. arabicus* (Houttuyn, 1782) favour demersal habitats and regularly ingoing in river mouths and estuaries (Iwatsuki, 2013). They reaching a maximum total length of 400 mm (Wang *et al.*, 2016). This species has been recorded from the Arabian Gulf area (Al-Salim and Jassim, 2013; Iwatsuki, 2013).

Notwithstanding of the increase in otolith weight asymmetry studies in the literature, information of otolith mass asymmetry on the yellowfin seabream investigated in the present study remains unknown in the Arabian Gulf area. In the current study, the value the otolith mass asymmetry was quantified for *A. arabicus* chosen for this study, which was collected from Khor al-Zubair area North-West region of the Arabian Gulf the marine waters. Also, the disproportion of this asymmetry was assessed throughout fish length.

MATERIALS AND METHODS

Description of sampling area
Khor al-Zubair is one of the four marine coastal areas of Iraq, which include the estuary of the Shatt al-Arab River at the city of Fao, the Khor Abdulla, and Um Qasar regions. Iraqi marine biodiversity has been changed by the region's geological history, position in the North-West Arabian Gulf and its physiographical intricacy. The Tigris and Euphrates Rivers convene at Qurnah to form the Shatt al-Arab River, which flows southward, entering the Arabian Gulf at the city of Fao. The coastal areas in the Khor al-Zubair region spread from sea-level to an elevation 3 m above sea level (Kukal and Saadallah, 1973). Until 1983, when the Shatt al-Basra canal was opened and linked the greater marsh areas in Southern Mesopotamia, the fluctuating course of the Euphrates made Khor al-Zubair a North-West marine extension of the Arabian Gulf (Al-Mussawy, 1991). Salinity values of this lagoon range between 32 and 38 and it is subject to a semi-diurnal tidal cycle with 2-3 m spring tides, similar to the Northern part of the gulf.

Fish sample collection
Fish samples of *A. arabicus* (120) and were collected from the commercial catch using small trawler (21 m length x 3.5 m width) provided with net of mesh size 2.5 cm working at from Khor al-Zubair area at the North-West region of the Arabian Gulf. Fishes were collected in the period February-July 2020 and at depth of 10-25 m. The method of Lychakov *et al.* (2006) was adopted in measuring the standard length of fishes before the removing of their otoliths. The otoliths were isolated from each side, washed in water, left to dry at room temperature, and then weighed on a Sartorius TE 313S analytical balance to an accuracy 0.0001 g. Alterations between left and right otolith mass assessments for each species was confirmed using t- test. Similarly, discrepancy of otolith weight between males and females was corroborated using t- test. The otolith mass asymmetry *(X)* was calculated from $X = (mr - ml)\ m\text{-}1$, where mr and ml are the otolith masses of the right and left otoliths and m is the mean mass of the right and left otoliths. Notionally, the X value can vary between -2 and 2, $X = 0$ signifies the nonappearance of mass asymmetry ($mr - ml$), and $X = -2$ or $X = 2$ exemplifies the maximal asymmetry (absence of one otolith). A positive value of X represents a larger mass for the right otolith mass than the left while a negative value shows the opposite. The connection between the absolute value of X and the otolith growth rate was examined. The association between otolith mass and fish total length, $m = a\ l + b$, was work out in order to assess the otolith growth rate, where m signifies the mass of the otolith, l for the total length of the fish, *"a"* for the coefficient indicating the growth degree of the otolith, and *"b"* for a variables for the sparid species in question.

RESULTS

The mean value of x is 0.0054 ± 0.0131, $n = 120$ and the value of IXI is 0.0177 ± 0.0152, $n = 120$. According to the regression analysis, there was no link between fish total length and both X (y = -7E-05x + 0.0206) ($P > 0.005$, $R^2 = 0.0114$) (Figure 1) and IXI (y = -7E-05x + 0.0031) ($P > 0.05$, $R^2 = 0.0252$) (Figure 2). The relation between the otolith mass difference (MR - ML), and the fish length is further complex than the relation between x and the fish length ($n = 120$, total length = 200-240 mm, $P > 0.05$, y = -1E-05x + 0.0032, $R^2 = 0.0090$) (Figure 3).

DISCUSSION

In recent years, the studies that dealt with otolith mass asymmetry were numerous and in all these investigations the otolith mass asymmetry estimates were shown to be in the range of $-0.2 < x < +0.2$ for quite a few marine and freshwater species (Lychakov *et al.*, 1988; Lychakov, 1992; Takabayashi and Ohmura-Iwasaki, 2003; Lychakov and Rebane, 2004; Lychakov and Rebane, 2005; Jawad *et al.*, 2011; Jawad and Sadighzadeh, 2013; Jawad, 2013; Jawad *et al.*, 2017; Al Balushi *et al.*, 2017). Additionally, the otolith weight asymmetry was less than 0.06 a value that agreed with the value of this phenomenon developed for great number of marine species (Lychakov *et al.*, 2006) and did not be definite by on otolith growth level. The otolith weight inconsistency increases with the fish length and this is peculiarity of the littoral and bottom fishes and not the pelagic fishes (Lychakov and Rebane, 2004). Lychakov and Rebane (2004, 2005) have revealed

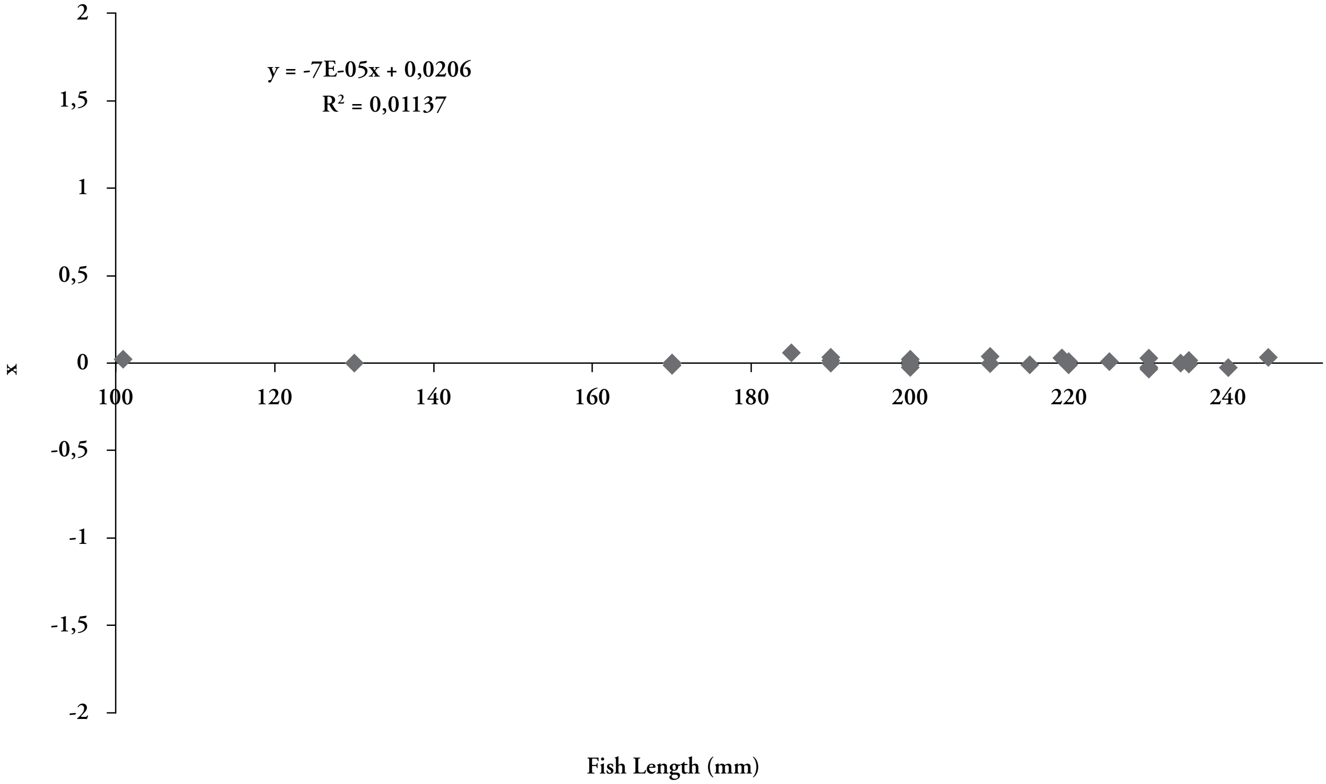

Fig. 4 – Saccular otolith mass asymmetry x in *Acanthopagrus arabicus* as a function of fish total length.

over the mathematical modelling that acoustic and vestibular operative of a fish ear can be reduced due to otolith weight inequality. However, in some fishes examined (Lychakov *et al.*, 2006), containing the species in question, otolith weight asymmetry is very low (IXI < 0.6), irrespective of fish length. This low level of otolith asymmetry is typical for utricular and lagenar otolith organs also in symmetric teleost fishes. Besides, Lychakov and Rebane (2005) have showed that only fishes that encompass the largest otoliths and IXI > 0.2 might, in theory, show difficulty with sound handling due to unsuitability and discrepancy of the movement of the two otoliths on both sides of the head of the fish. Consequently, the majority of fish species can getaway functional incapability as they have otolith mass asymmetry below serious value.

Lychakov *et al.* (2006) suggested that otolith mass asymmetry exhibits resemblances and variations between the marine roundfishes and flatfishes (Lychakov *et al.*, 2008). They concluded that the saccular otolith weight asymmetry is not subjective by the fish length or the otolith growth rate.

Similarly, further marine fish (Lychakov *et al.*, 2008), the value of *X* obtained in the present study falls in a range between -0.2 and +0.2. The otolith weight asymmetry, though, was less than 0.05, a value that concurs with that attained for a large number of marine species (Lychakov *et al.*, 2006). The otolith weight discrepancy increases with the fish length as is the case for other fish species (Lychakov and Rebane, 2004). Lychakov and Rebane (2004, 2005) suggested in their mathematical model that the acoustic and vestibular functioning of a fish ear can decrease due to otolith weight asymmetry. However, in the majority of fish species (Lychakov *et al.*, 2006), including the species studied, the otolith weight asymmetry is very little (IXI < 0.5), regardless of the fish length. This low level of otolith asymmetry is characteristic of the utricular and lagenar otoliths. Conversely, Lychakov and Rebane (2005) specified that only fish with the biggest otoliths and IXI > 0.2 could, in theory, have complications with sound management owing to the unsuitability and conflict of the mobility of the two otoliths on both sides of the head.

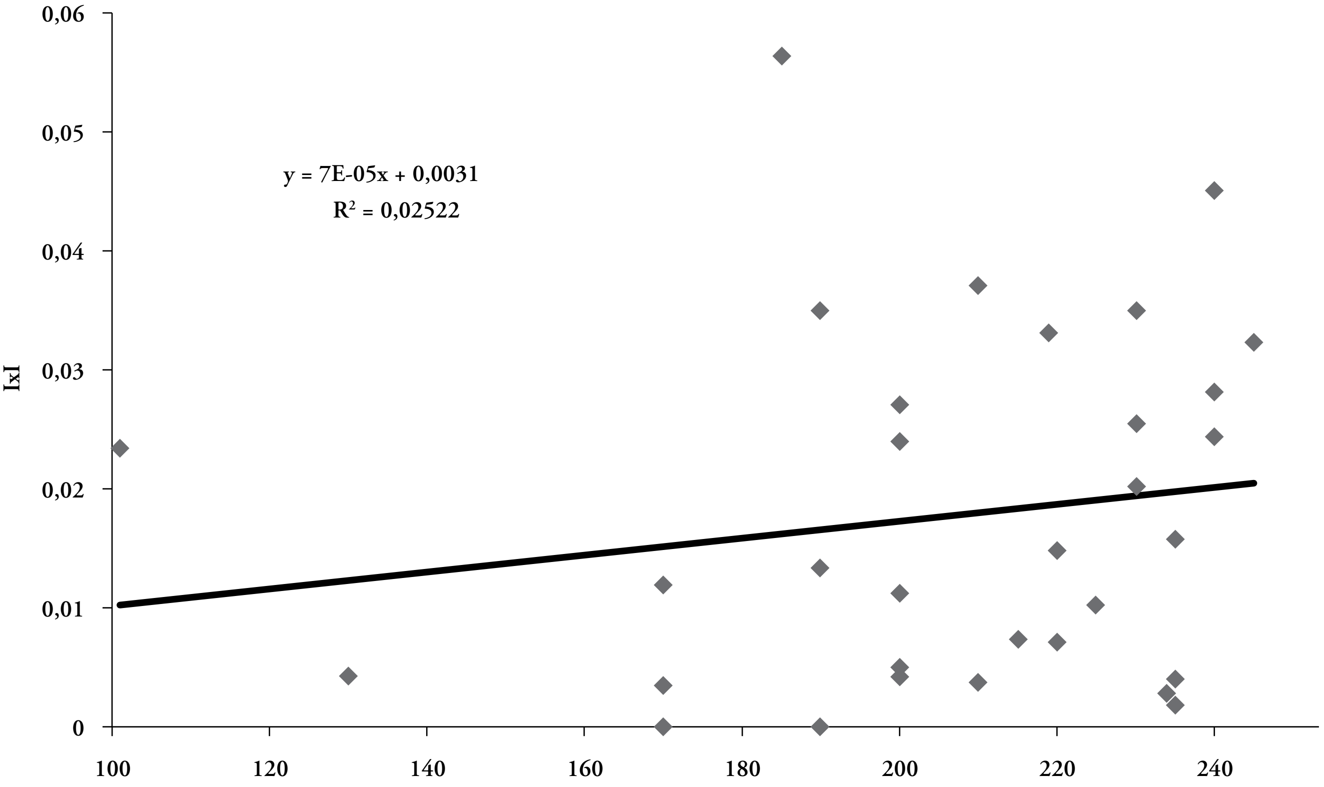

Fig. 5 – Absolute otolith mass asymmetry in *Acanthopagrus arabicus* as function of fish total length

Thus, furthermost teleost species can escape an operating ineffectiveness as they have an otolith weight asymmetry lower than the crucial value.

The impact of otolith weight asymmetry on the vestibular performance was studied and clarified by Lychakov and Rebane (2000, 2004) in their mathematical model that showed the reaction of the ellipsoid-shaped otolith to the action of the force of gravity. They calculated the change between the static displacement of the right and left ellipsoid-shaped otoliths and found that it connected to the otolith weight asymmetry. This displacement modification, they determined, could be the main source of the different release features of the paired otolithic organs and hereafter the performing of otolith asymmetry.

The results of this study on otolith weight asymmetry in *A. arabicus* show that it does not rely on the fish size. This agrees with the results acquired by other researchers on many marine and freshwater fish species (Lychakov and Rebane, 2004, 2005; Lychakov *et al.*, 2006; Jawad, 2013; Jawad and Sadighzadeh, 2013, Jawad *et al.*, 2011, 2012). However, the association between otolith weight difference and fish length is more complex. In the present study, no relationship between fish length and otolith mass has been found. Such an outcome in support of the results attained by Lychakov and Rebane (2004, 2005) on some teleost species. Lychakov *et al.* (2006) suggested that a small link might be owing to the small sample used in the study or when specimens do not visibly deviate in size. Both endorsements can be related to our dataset as only 120 specimens with total lengths between 200-240 mm were used.

Otolith mass asymmetry can have an effect on the life of a fish, so the investigation about the asymmetry of fishes is very vital. In the present study, the average otolith mass asymmetry of *A. arabicus* from Khor al-Zubair area, Iraq, North-West region of the Arabian Gulf was lower than that attained on an individual basis. These outcomes disclose that the population of the species in question is under environmental impact.

Pollution in Iraq is a problem that facing the whole world owing to the impact of on environ-

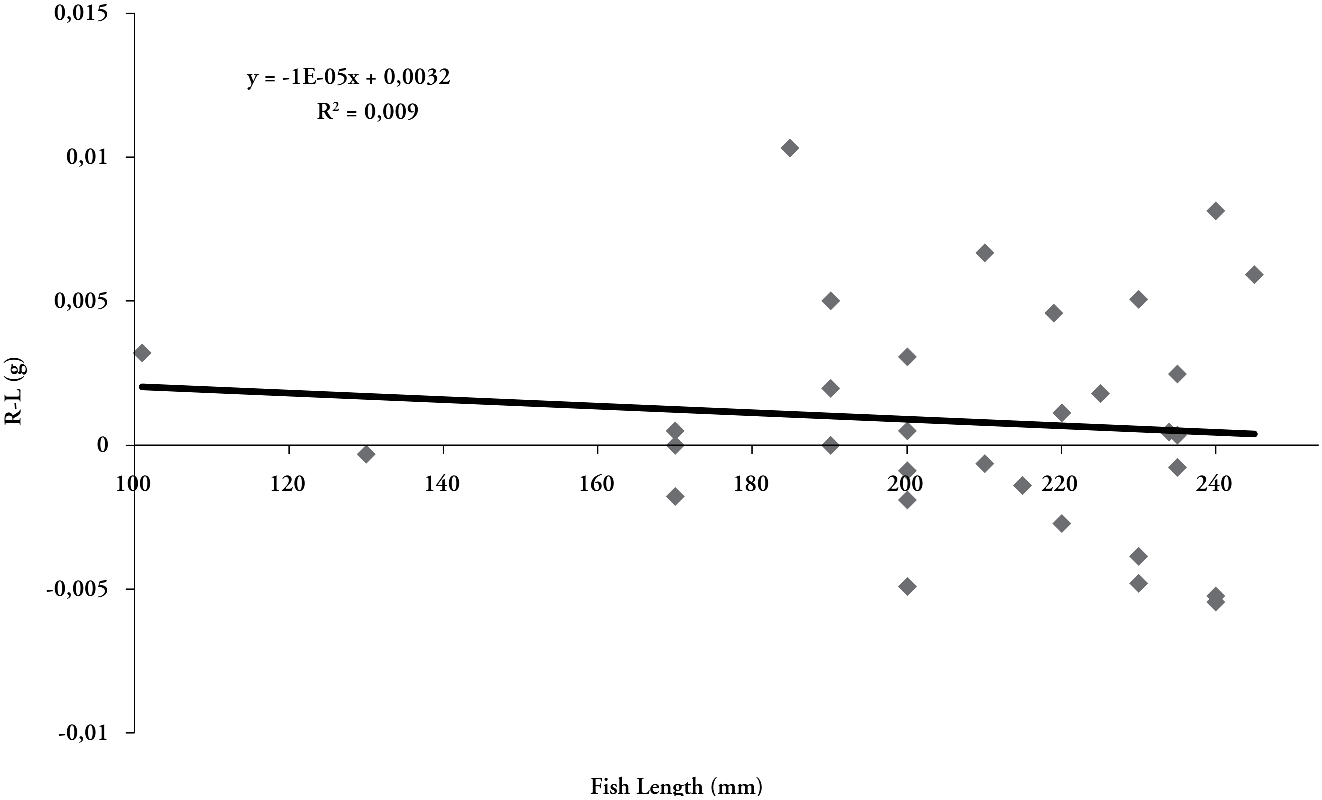

Fig. 6 – Saccular otolith mass difference in *Acanthopagrus arabicus* as a function of fish total length

ment. Pollution of different types can upsetting the life of the biota in way or another. Though bearing in mind the prominence of water in the life of living organisms, the results of water pollution forms the most chief type of pollution in this aspect. The only way to find out about the level of pollution in the aquatic environment is by studying the impact of the adverse factors on the biota. Such events can be applied in both the terrestrial and aquatic habitats. These influences are also identified in controlling the physiology, histology and anatomy, behavioral patterns and nutritional behaviors of living things (Yedier *et al.*, 2018).

Marine areas of Iraq in general, where the fish samples in the study at hand were collected are known for their high pollution level. Pollution chiefly hydrocarbon was distinguished over years in this area (Al-Jaberi *et al.*, 2014; Abdulnabi, 2016; Al-Khion *et al.*, 2016) and in the Kuwaiti marine environment (Saeed *et al.*, 1999; Beg and Al-Ghadban, 2003; Al-Yamani, 2008). Such source of pollution is started from the course of exporting oil using the huge oil tankers visiting Iraqi ports for loading. Such pollution can cause collapse of the quality of water resources and the constant change of the aquatic ecosystem (Turgut and Özgül, 2009). Pollution could also be a reason for pressure cause on the aquatic animals, which in turn can disturb the growth constancies in fish. Earlier studies in this area have revealed a direct connection between environmental impact and asymmetry as an outcome from pollutions (Jawad *et al.*, 2012).

Further investigations with larger numbers of specimens and a wider series of body size are imperative to find the association between the otolith weight difference and the fish length, particularly in view of the absence of studies on otolith weight asymmetry in the marine waters of Iraq. This study suggests a starting point for future investigations in marine fish species in Iraq and will allow researchers to make links between species in Iraq and species living in the neighbouring areas. A management plan is instantly needed in order to restore a healthy environment in the marine waters of Iraq.

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Availability of data and material

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Code availability

No software application or custom code were used

Authors' contributions

L.A.J. put the idea of the work, designed the sampling, write the manuscript.

A.Q. collects the samples, measure the fish, extracted otolith and assist in the statistical analysis.

References

ABDULNABI Z.A., 2016. Assessment of some toxic elements levels in Iraqi marine water. Mesopotamian J Mar Sci 31: 85-94.

AL BALUSHI A. H., JAWAD L.A., AL BUSAIDI H.K., 2017. Otolith Mass Asymmetry in Lutjanus ehrenbergii (Peters, 1869) Collected from the Sea of Oman. Intern. J Mar Sci 7.

AL-JABERI M.H., AL-DABBAS M.A., 2014. Assessment of heavy metals pollution in the sediments of Iraqi coastlines. Science 3: 9.

AL-KHION D.D., AL-ALI B.S., AL-NAGAR G., AL-SAAD H.T., AL-ANBER L.J., 2016. Polycyclic aromatic hydrocarbons in some fishes from the Iraqi marine waters. Intern J Sci Res 7: 1911-1917.

AL-MUSSAWY S.N., 1991. About Khor Al-Zubair classification and the ability of determining it's approaching since its different development stages. Oceanography of Khor Al-Zubair (PhD thesis). University of Basra, Iraq (in Arabic).

AL-SALIM N.K., JASSIM A.A.R., 2013. *Acanthopagrus latus* (Houttuyn, 1782) (Perciformes: Sparidae) a new host for the trematode *Erilepturus hamati* (Yamaguti, 1934) Manter, 1947 in Iraqi marine waters. Basrah J Agri Sci 26: 172-177.

AL-YAMANI F., 2008. Importance of the freshwater influx from the Shatt Al-Arab River on the Gulf marine environment. In *Protecting the Gulf's marine ecosystems from pollution*. Birkhäuser Basel: 207-222.

BEG M.U., AL-GHADBAN A.N., 2003. Impact of draining of Iraqi marshes on sediment quality of Kuwait's Northern marine area. Bull Environ Contam Toxicol 71: 60-67.

GRØNKJÆR P., SAND M.K., 2003. Fluctuating asymmetry and nutritional condition of Baltic cod (*Gadus morhua*) larvae. Mar Biol 143: 191-197.

IWATSUKI Y., 2013. Review of the *Acanthopagrus latus* complex (Perciformes: Sparidae) with descriptions of three new species from the Indo-West Pacific Ocean. J Fish Biol 83: 64-95.

JAWAD L.A., 2013. Otolith Mass Asymmetry in *Carangoides caerulepinnatus* (Rüppell, 1830 (Family: Carangidae) Collected from the Sea of Oman. Croatian J Fish 71: 37-41.

JAWAD L.A., SADIGHZADEH Z., 2013. Otolith mass asymmetry in the mugilid fish, *Liza klunzingeri* (Day, 1888) collected from Persian Gulf near Bandar Abbas Anal Biol 35: 105-107.

JAWAD L.A., AL-MAMRY J.M., AL-MAMARI H.M., AL-YARUBI M.M., AL-BUSAIDI H.K., AL-MAMARY D.S., 2011. Otolith mass asymmetry in *Rhynchorhamphus georgi* (Valenciennes, 1846) (Family: Hemiramphidae) collected from the Sea of Oman. J Black Sea / Med Environ 17: 47-55.

JAWAD L.A., AL-MAMRY J.M., AL-MAMARI D., AL-HASANI L., 2012. Study on the otolith mass asymmetry in *Lutjanus bengalensis* (Family: Lutjanidae) collected from Muscat City on the Sea of Oman. J FisheriesSciences.com 6: 74-79.

JAWAD L.A., MEHANNA S.F., ABU EL-REGAL M.A., AHMED Y.A., 2017. Otolith mass asymmetry in two parrotfish species, *Chlorurus sordidus* (Forsskål, 1775) and *Hipposcarus harid* (Forsskål, 1775) from Hurghada, Red Sea Coast of Egypt, Intern. J Mar Sci 7: 200-204.

KUKAL Z., SAADALLAH A., 1973. Aeolian admixtures in the sediments of the Persian Gulf. In Purser B.H. (Editor), The Persian Gulf. Berlin: Springer-Verlag: 115-121.

LYCHAKOV D.V., 1992. Morphometric studies of fish otoliths in relation to vestibular function. Zhurnal Evoliutsionnoi Biokhimii I Fiziologii 28: 531-539.

LYCHAKOV D.V., REBANE Y.T., 2004. Otolith mass asymmetry in 18 species of fish and pigeon. J Grav Physiol 11: 17-34.

LYCHAKOV D.V., REBANE Y.T., 2005. Fish otolith mass asymmetry: morphometry and influence on acoustic functionality. Hearing Res 201: 55-69.

LYCHAKOV D.V., BOYADZHIEVA-MIKHAILOVA A., CHRISTOV I., PASHCHININ A.N., EVDOKIMOV I.I., MAT-

KOV A.A., 1988. Changes in the otolith apparatus of rat and fish after prolonged exposure to acceleration. Kosmicheskaya biologiya I Aviakosmicheskaya Meditsina 22: 27-33.

LYCHAKOV D.V., REBANE Y.T., LOMBATE A., FUIMAN L.A., TAKABAYASHI T., 2006. Fish Otolith asymmetry: morphometry and modelling. Hearing Res 219: 1-11.

LYCHAKOV D.V., REBANE Y.T., LOMBATE A., DEMESTRE M., FUIMAN L., 2008. Saccular otolith mass asymmetry in adult flatfishes. J Fish Biol 72: 2579-2594.

NOLF D., 1985. Otolith piscium. In: Schultze H.P. (Editor), Handbook of Paleoichthyology, Vol. 10, Stuttgart, Gustav Fisher Verlag: 1-145.

POPPER A.N., LU Z., 2000. Structure-function relationships in fish otolith organs. Fish Res 46: 15-25.

SAEED T., AL-GHADBAN A.N., AL-SHEMMARI H., AL-MUTAIRI M., AL-HASHASH H., 1999. Preliminary assessment of the impact of draining of Iraqi marshes on Kuwait's Northern marine environment. Part II. Sediment associated pollutants. Water Sci. Technol. 40: 89.

TAKABAYASHI A., OHMURA-IWASAKI T., 2003. Functional asymmetry estimated by measurements of otolith in fish. Biol Sci Space 17: 293-297.

VALENTINE D.W., SOULE M.E., SAMOLLOW P., 1973. Asymmetry in fishes: a possible statistical indicator of environmental stress. Fish Bull 71: 357-370.

WANG J.Q., HUANG L.M., LI J., ZHANG Y.Z., ZHU G.P., CHEN X.J., 2016. Length-weight relationships of 45 fish species in the Min River Estuary, East China Sea. J Appl Ichthyol 32: 131-133.

YEDIER S., BOSTANCI D., KONTAŞ S., KURUCU G., POLAT N., 2018. Comparison of Otolith Mass Asymmetry in Two Different *Solea solea* Populations in Mediterranean Sea. Ordu Üniversitesi Bilim ve Teknoloji Dergisi 8: 125-133.

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Critical inventory of *Loxodonta* and *Elephas* (Mammalia, Proboscidea) cranial remains in the collections of the Museo Civico di Zoologia of Rome (Italy)

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ABSTRACT

*The osteological collection of the Museo Civico di Zoologia of Rome (MCZR) counts 2 complete skeletons, 4 skulls with mandible, 4 skulls, 5 mandibles, 1 molariform tooth, and 11 more or less complete tusks of extant elephants. This research aims to identify to which elephant among those that lived in captivity and died at the Zoological Garden of Rome (ZGR) the cranial material belongs. The results of the qualitative and quantitative analysis, the inferred sex and age estimates permit to assert that the elephant cranial remains of MCZR's osteological collections belong to at least four taxa (*Loxodonta africana, Loxodonta cyclotis, Elephas maximus maximus, *and* Elephas maximus sumatranus*). 4 Asian and 3 African among the 14 Asian and the 6 African elephants that died at the ZGR from 1910 to 2012 were identified, while for 2 Asian elephants the identification was doubtful or highly uncertain. In addition, we acknowledged the presence of a large cranium of an African bush male of unknown provenance, a skull of an African forest male that lived at the Zoo of Naples from 1952 to 1955, and of a skull of a very young Asian elephant of unknown origin.*

Key words: Loxodonta africana, Loxodonta cyclotis, Elephas maximus maximus, Elephas maximus sumatranus, *basic morphology, dimorphism, age estimates.*

1. INTRODUCTION

The vertebrate osteological collection stored in the Museo Civico di Zoologia of Rome (MCZR) represents a valuable scientific zoological heritage available to neontologists and palaeontologists. Among other mammalian specimens, some cranial remains of African and Asian elephants collected in the last century since the institution of the Museum are of particular interest. To date, the majority of them have been neither described nor listed in any inventory to date.

The Museo Civico di Zoologia of Rome was officially opened in 1932 inside the "Giardino Zoologico" in Rome (ZGR). At that time, the collections mostly consisted of specimens "rented" by the Institute of Zoology of Rome University (Vomero, 1988; Carlini & Vomero, 2014). According to Carruccio (1913), director of the University Zoological Museum, the elephant material stored in the Museum consisted of three tusks of *Loxodonta africana* (possibly sent to MCZR) and a skull of a young elephant from the Hawash River, Ethiopia (Carruccio, 1894).

The skull mentioned above was not sent to the Museo Civico di Zoologia (as most of the osteological material; see Gippoliti & Bruner, 2008) and it is probably the same currently kept at the Museo di Antropologia "Giuseppe Sergi" of Sapienza University. The Museo Civico di Zoologia instead received in 1932 from the Institute of Zoology the skull of an adult Asian elephant (ex MCZR 6703), probably one of the elephants that died in the zoo while the Institute was host of the same Giardino Zoologico (1920-1927; Vomero, 1988). Since the beginning of its activities, MCZR has begun to increase its collections by preserving osteological materials of animals that lived and died in ZGR (Figure 1). Regrettably, specimens sometimes lack the minimal information needed to identify without any doubt the individual to which the osteological material belongs. This is, for instance, the case of some among the elephants that died at the ZGR between 1910 and 2012 (6 African individuals, died between 1910 and 1991; and 12 Asian elephants died between 1910 and 2012)

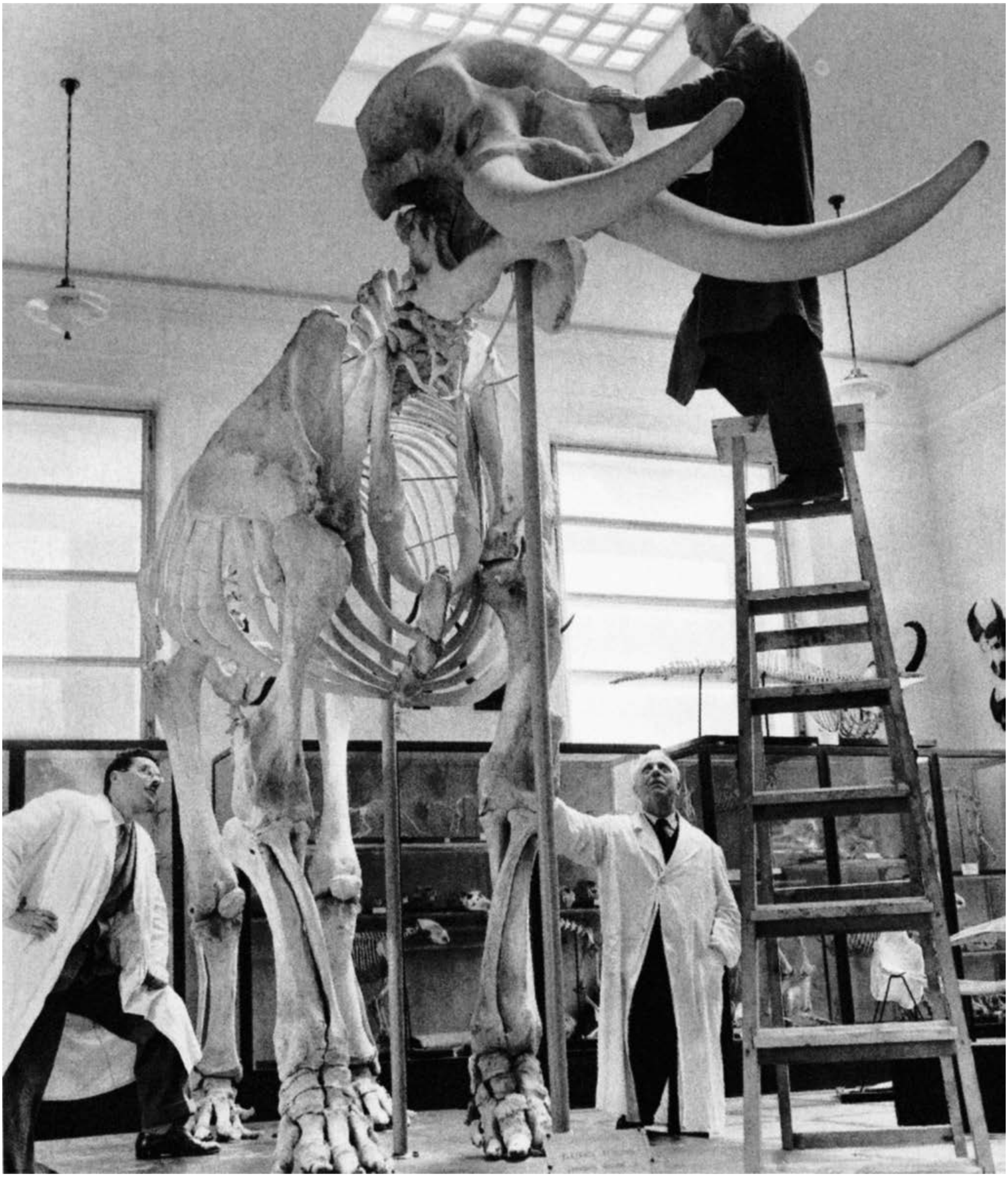

Fig. 1 – The assembly of the skeleton of the African bush elephant Toto is almost ready, 1952 (photo courtesy of Mauro Picone)

(Gippoliti, 2010 and personal data), whose cranial remains, lacking informative labels, might be some of those present today in the MCZR's vertebrate osteological collection. Some others possibly belong to specimens moved to MCZR from other Museums/Institutions or sent as a present by private collectors.

Some elephant specimens from the MCZR's osteological collection have already been utilized for comparative purposes in zoological and paleontological studies (e.g. Bronzini, 1975; Ferretti & Debruyne, 2011). Others, such as the male named "Toto", were often discussed in the specialist literature during their lifetime (Knottnerus-Meyer, 1911 and 1925; de Beaux, 1912). It is, therefore, of pivotal interest to properly recognize each specimen by using both data that are potentially available from elephants that died in the ZGR, and morphological and metric information useful for inferring individual age and sex.

The renewed interest in elephant alpha taxonomy (especially in *Loxodonta*) and phylogenetic relationships inside Proboscidea (cf. Palkopoulou *et al.*, 2018) arisen in recent decades, suggests the necessity of a reappraisal of the materials kept in museums to update the identification of elephants specimens according to the most recent taxonomical view (see below).

Accordingly the aim of this research is two folded:

- to revise the taxonomical identification of cranial elephant remains present in the MCZR collection to verify whether it includes or not any skull from the five African forest elephants known to have been held in captivity in Italy, two in ZGR and three in the Naples Zoo (Schürer, 2017);
- to infer ontogenetic age and sex of each specimen, paying particular attention to those of known age and sex, also in order to test the validity of methods proposed in literature to infer these data from cranial and dental remains.

2. SOME REMARKS ON TAXONOMY AND DISTINCTIVE CRANIAL FEATURES OF *LOXODONTA* AND *ELEPHAS*

2.1. Taxonomical notes

Currently, there is an almost general consensus on recognising two genera and three species of extant elephants, the Asian *Elephas maximus*, Linnaeus, 1758, and the African savannah, or bush, *Loxodonta africana* (Blumenbach, 1797*),* and the forest, *Loxodonta cyclotis,* (Matschie, 1900), elephants.

Most scientists believed that the number of species created by God was limited at the time when Linnaeus (1758) created the species *Elephas maximus*. The Swedish naturalist apparently considered that all surviving elephants belonged to a single species (Linnaeus, 1758). This is possibly the reason why the species *Elephas maximus* was based on a foetus of an African elephant and an Asian individual. According to Shoshani and Tassy (2005), the name *Elephas maximus* itself combines the characteristics of both Asian and African elephants, being *Elephas* referred to the Asian elephant, and *maximus* to the African elephant, the largest in size (Shoshani & Tassy, 2005: 354, 360).

Recently, Cappellini *et al.* (2014) analysed the syntype specimens of *E. maximus* by means of morphology, ancient DNA (aDNA), and high-throughput ancient proteomic analyses. Results obtained confirmed that the complete foetus, preserved in ethanol, actually belongs to genus *Loxodonta*. They designated as lectotype of the species *E. maximus* a nearly complete skeleton displayed at the Natural History Museum of the University of Florence and confirmed the skeleton was the same described by Ray (Ray, 1693) and later cited by Linnaeus in 1758 (Cappellini *et al.*, 2014; see also Gentry *et al.*, 2014).

The geographic separation of Asian elephant populations led to some differentiation, being the continental India population genetically closer to each other than those inhabiting islands (e.g. Sri Lanka, Sumatra, Borneo) (see e.g. Barriel *et al.*, 1999; Fernando *et al.*, 2000 and 2003; Vidya *et al.*, 2005). Three subspecies have been already recognized (Shoshani & Eisenberg, 1982): the nominal, most advanced subspecies *Elephas maximus maximus* from Sri Lanka, the continental subspecies *Elephas maximus indicus* Cuvier, 1797, and *Elephas maximus sumatranus* Temminck, 1847 from Sumatra, the most primitive of the three subspecies (see Deraniyagala, 1955; Shoshani, 2000; Shoshani & Tassy, 2005 and references therein; Todd, 2010). The Borneo elephant population (by some identified as *Elephas maximus borneensis* Deraniyagala, 1950) appears to be genetically distinct as well, "with molecular divergence indicative of a Pleistocene colonisation of Borneo and subsequent isolation" (Fernando *et al.*, 2003), but actual taxonomic status of the alleged subspecies remains unclear.

Loxodonta populations' geographic range, which once extended from the Mediterranean to southernmost Africa, is now fragmented and includes African territories South of the Sahara desert (Barnes *et al.*, 1999). The geographical range of the forest and savannah elephant populations apparently does not overlap, and these elephants live in different habitats, and have different size and morphologies.

The taxonomical value of these differences, and in turn the taxonomical rank (subspecies or species) of the two African elephants, has been poorly defined or debated. Even the original descriptor of the forest elephant, Paul Matschie, a well-known taxonomical "splitter", seems to have been uncertain whether or not the forest elephant might belongs to a *bona fide* species, since the German zoologist utilised both the specific name *Elephas cyclotis* and the subspecific name *Elephas capensis cyclotis* in his paper (Matschie, 1900). The specific name *Elephas capensis* had been proposed for the South African elephants from the Orange River region (Cuvier, 1798). Some of the morphological differences between the two African species pointed out by Grubb *et al.* (Grubb *et al.*, 2000) were already noted by Lyddeker (Lyddeker, 1907) in his comparison between specimens from Albert Nyanza (Eastern Belgian Congo, now Democratic Republic of Congo) and Sudan (by the author respectively named *Elephas africanus albertensis* Lyddeker, 1907 and *Elephas africanus oxyotis* Matschie, 1900), and critically described by Francisco Frade and Joseph Allen, who listed a number of differences in skull, mandible tusks and molariform teeth (Frade, 1931; Allen, 1936). Although the taxonomy and morphology of *Loxodonta* have been frequently discussed in the literature, the systematic assessment is actually based on a few studies on a few specimens with large geographic gaps, as for instances, in Western Africa.

Genetic data and recent extensive morphological analysis have increased discussion about the status of *L. cyclotis*, now considered by most researchers to be a species distinct from the typical savannah *L. africana* (e.g. Barriel *et al.*, 1999; Grubb *et al.*, 2000; Roca *et al.*, 2001, 2005; Eggert *et al.*, 2002; Ishida *et al.*, 2011; Gugala *et al.*, 2016; Roca, 2019), and possibly the most primitive (Shoshani, 2006). According to this author (Shoshani, 2006: 8), "*Loxodonta cyclotis* is more primitive than *L. africana* for these reasons: forest dweller, smaller, slender, down-pointing tusks and other skull characters discussed by Grubb *et al.,* 2000".

The morphological differences and the high divergence at the nuclear genetic level validate the existence of two distinct extant elephant species in Africa. The actual taxonomic status of some African elephant populations, on the other hand, is somewhat uncertain and warrants further investigation (Roca, 2019). Some authors discussed the possibility that the populations of West Africa may belong to a third specie due to some peculiarity of their DNA (Eggert *et al.*, 2002), a hypothesis also supported by the somatic differences of these elephants (Gippoliti, pers. obs.). The West African forest elephant populations would have diverged about 2.4 Myr ago, confirming a long history of isolation of West African biomes from the rest of the continent (Barej *et al.*, 2014) that also has crucial consequences for conservation (cf. Gippoliti *et al.*, 2018).

2.2. *Elemental taxonomical and dimorphic cranial features*

2.2.1. MORPHOLOGICAL TRAITS USEFUL FOR TAXONOMICAL IDENTIFICATION

Elephas and *Loxodonta* genera clearly differ in molariform tooth morphology and the overall shape of the skull and mandible, partially as a result of the dissimilar development of tusks and hypsodonty of molariform teeth. The differences are definitively more marked and evident in the adult male crania, and less pronounced in female and young individuals.

The male individuals of *Elephas*, for instance, basically differ from those of both the African elephant species in having:

- a more dorso-ventrally elongated and anterior-posteriorly compressed skull;
- a cranium apex medially concave, with a more evident parietal-occipital crest;
- narrower frontal bones showing a concave outline in lateral view; higher positioned external nares;
- narrower nasal bones;
- smaller orbital fossa;
- more expanded parietal-occipital region;
- deeper, enlarged, and lower positioned nucal fossa;
- rounded, higher positioned and less posteriorly protruding condyluses;
- foramen magnum opening ventrally;
- longer and less expanded premaxillary bones, with a nearly parallel lateral outlines, gently curved distally, and a subtriangular;
- elongated incisive fossa.

The mandible of the Asian elephant is short with inflated corpus, medially curved rami, forming with the corpus an angle less than 90°, concave and anterior-medially curved coronoid processes that are located at the midpoint of the corpus, short, narrow and inferiorly directed mandibular symphysis with U-shaped symphyseal fossa, deep and wide masseteric fossa, pterygoid muscle inserted on the posterior and lateral sides of the ramus, and wide and rounded mandibular foramen.

In *Loxodonta*, instead, the mandible is long and slender with divergent rami, forming with the corpus an angle of about 90°, quite straight coronoid processes, gradually widening to lateral sides and more posteriorly located, quite long, wide, and anteriorly directed mandibular symphysis with a nearly V-shaped symphyseal fossa, shallow and less wide masseteric fossa, pterygoid muscle inserted on the posterior lateral of the ramus, and elongated and narrow mandibular foramen.

Elephas and *Loxodonta* clearly differ in molariform tooth shape and enamel figures present on the occlusal surface of worn laminae. The Asian elephant teeth (from the second to the ultimate) are more hypsodont, quite broader, more curved and oval-shaped than those of *Loxodonta,* have more plates, covered by thick cement, separated each other by narrow cement valley. The enamel figures of worn plate are not lozanged, being the mesial and distal outlines nearly parallel, the enamel is thinner, and more folded. In the less worn laminae, isolated columns persist for longer than in *Loxodonta* where, instead, enamel rings/loops appear at earlier wear stage.

The main cranial features distinguishing *L. cyclotis* from *L. africana* have been already noted (Frade, 1931, 1933a,b, 1955) and summarised (Allen, 1936: 35) as follows. The skull "of the Forest Elephant is much flattened and lengthened (instead of highly vaulted and shortened); temporal ridges very divergent, the distance between them great as compared with that between the orbital processes (in the Bush Elephant the temporal ridges are more approximated, the distance between them short in comparison with that between the orbital processes); zygomatic arches less prominent. The symphysis of the mandibles presents rather striking differences. In the Forest Elephant it is longer and more spout-like; the alveolar line on each side is continued forward and steeply downward as a sharp ridge, the two of opposite sides when seen from above at first parallel, then converging rather evenly toward the tip of the long slender symphysis, or they may together form the arms of a long V. In the Bush Elephant, the two ridges are at first carried forward more nearly parallel, forming a wide trough, then come together more abruptly forward to form a shorter spout at the symphysis".

Some of the above listed morphological features could be considered statistically valid, although they are not only "subject to a certain variation with age", as noted by Allen, but may also be related to sex and, sometimes, even to individual variability. In addition, the skull of *L. cyclotis* shows, with respect to that of *L. africana*, a less rounded vault, with a steeply sloped occipital, a broader and quite longer forehead, and a wider nucal fossa. The premaxillary bones are inferiorly directed with a nearly straight dorsal outline, almost in line with the external nares, are moderately separated at the dorsal edge, with lateral outlines more curved distally, and the incisive fossa is longer and rectangular in shape. The lacrimal protuberance (*processus dorsalis*) is absent.

Some differences in the skull shape, particularly those shown by premaxillary bones, depend on the different development of tusks (longer, less curved and downwards directed in *L. cyclotis),* characterising the two African species. The molariform teeth are almost similar in general morphology, and no significant differences exist in size and number of plates between the two species (cf. Morrison-Scott, 1947: 520). According to a recent review (Todd, 2010), the molariform teeth (premolars and molars) of the African forest elephants have fewer plates, relatively thick enamel, laminae more separated, enamel figures tapered at the anterior end. These features seem, however, subject to some individual variability.

A few differences, but with some diagnostic significance at subspecies level, distinguish both the nominal subspecies *E. m. maximus* and the Indian *Elephas maximus indicus*, showing a very similar cranial morphology, from the Sumatran elephant *Elephas maximus sumatranus.* According to a recent review (Todd, 2010), the latter basically differs in having a more dorso-ventrally elongated skull, with a flatter, but evidently two-domed skull vault, longer forehead, less high and flat occipital with a oval nucal fossa, higher maxillary region, markedly posterior-anteriorly downwards inclined zygomatic arch, and dorsally moderately concave, outward directed premaxillary bones (see Todd, 2010, Fig. 21-23 for additional minor differences). According to Shoshani (Shoshani, 2006: 8), "*Elephas maximus sumatranus* is possibly the most primitive Asian subspecies for these reasons: forest dweller, smallest, has largest number of ribs, possibly has highest incidence of tusks, has least depigmented skin and other characters discussed by Deraniyagala (1955)".

2.2.2. SEXUAL DIMORPHIC MORPHOLOGICAL TRAITS

The most evident sexual differences in extant elephants are related to size and tusk development. Asian and African male elephants are larger than females. *E. maximus* females generally lack tusks, although some, about 50% of them, may have short tusks without pulp inside, known as tushes. African females generally have tusks that are quite shorter and less robust than those of males. Tusklessness in bush elephant females, a phenomenon rarely observed in the past, has continuously been increasing during the second half of the last century and at present time, especially in populations whose size decreased after severe poaching. Some consider the rapid increase in its frequency to be a phenotypic indicator of underlying genetic drift, a kind of human-driven natural selection, whereas others believe that selective hunting cannot provide adequate explanations, at least for some populations, considering tusklessness as a possible result of non-selective genetic changes in small-sized, isolated populations (see e.g Jachmann *et al.*, 1995; Owens & Owens, 2009; Raubenheimer & Miniggio, 2016 for a discussion).

The morphological features that differentiate males and females of African and Asian elephants are at least partially related to the size difference and tusk development. In *E. maximus,* the female skull has a more rounded vault (without any evident medial concavity in the parietal-occipital crest) and occipital region, proportionally wider and more convex forehead, less robust nasal and especially premaxillary bones. All the insertion/origin areas of muscles are less marked.

The same occurs in the skull of *Loxodonta* females, where the dorsal outline of the vault is more rounded than in males, both in frontal and lateral view, with a scarcely detectable parietal-occipital crest, wider fronthead, and less massive premaxillary bones, with divergent but nearly straight sides and a smooth distal border, and an oval incisive fossa.

3. Material and methods

3.1. Material

We analysed the skulls and mandibles of Asian (one complete cranium, four skulls, and four mandibles) and African (four complete crania plus one mandible and one isolated molariform tooth) elephants kept in the Osteological Collection of the MCZR. Two other crania belong to individuals (an adult male of *L. africana,* MCZR OS.13011, and a stillborn *E. maximus*, MCZR OS.13012) whose skeletal bones were almost fully preserved. These skeletons will be described in depth elsewhere.

3.2. Methods

3.2.1 ANATOMICAL TERMINOLOGY

In the synthetic description of crania (skulls and mandibles) we followed the anatomical nomenclature as in van der Merwe *et al.* (van der Merwe *et al.*, 1995). The bony crest dorsally bounding the forehead in *E. maximus,* extraordinarily developed in Pleistocene Eurasian *Palaeoloxodon* elephants, and interpreted as a thickening of the parieto-occipital line (nuchal line) (Ferretti, 2008), is herein named the parietal-occipital crest (Todd, 2010).

Elephant cheek teeth are continuously replaced, namely, they are polyphyodont animals that have cycles of tooth rotation throughout their lives, showing a pattern of dental ontogeny that is unique among mammals. The teeth, morphologically similar, develop sequentially over a period of about 50 years, progressively increasing their size and number of plates. Teeth displace horizontally in the maxillary bones and mandible in a series that moves gradually forwards through the alveolus. The terminology adopted to identify teeth may vary. Many authors name the first three molariform teeth, developmentally homologous to deciduous premolars, DP2/dp2, DP3/dp3, and DP4/dp4 (dm in Maglio, 1973) and generally the last three upper and lower teeth M and m respectively, numbering them from 1 to 3 (e.g. Maglio, 1973).

The first three teeth are molariform, and are suppressed rather than lost during the molars' horizontal progression and displacement (possibly atavistic premolars are only recorded twice in *Mammuthus*) (Sanders, 2018). Due to such peculiar replacement and the substantial morphological and structural similarity of premolars and molars in elephants, some authors prefer to identify and name the molariform teeth according to the full complement of six cheek teeth per jaw quadrant (i.e., M1 to M6 and m1 to m6, respectively). Although the latter nomenclature is not preferred by the majority of specialists, we have chosen to indicate the upper and lower molariform teeth as M1 to M6 and m1 to m6 respectively.

The tiny plates present at the mesial and distal ends of tooth, which do not extend to the base of the crown, are known as "talons". The small posterior lamella that extends to the roots present on the distal side of the last molar (M6/m6) is termed "platelet" (Lister & Van Essen, 2003).

3.2.2. MEASUREMENTS

All available teeth were measured, including those from both sides of the skull and mandible. Measurements of molariform teeth were taken according to the following references (Maglio, 1973; Lister, 1996) with minor modifications. The averaged Lamellar Frequency (LFm = number of plates in 100 mm in molariform teeth with a total length >/= 100 mm, number of plates in 50 mm in teeth with a length < 100 mm) was estimated averaging the LF measured on the occlusal (LFo), lateral (LFl), and medial (LFm) surfaces. This was done in order to avoid possible mistakes due to the convergence of plates toward the top of the crown in lower molariform teeth, and to the anomalous juxtaposition of plates shown by some specimens.

It is worth noting that the wear may lead to the loss of some anterior plates and, in turn, can lead to an underestimation of the original number of plates. The observation of the plates still supported by the anterior root, if present, may help in the correct estimation of the number of lost plates, but it could be difficult, if not impossible, in the case of molariform teeth still inserted in the alveolus, as those we have analysed.

The dimensions of MCZR teeth were compared with data available in the literature (Morrison-Scott, 1947; Roth & Shoshani, 1988; Lindeque, 1991). Measurements are expressed in mm.

3.2.3 AGE AND GENDER

The dental progression and degree of wear of elephant molariform teeth offer a means of estimating the ages of individuals, if the teeth are correctly identified (see Roth & Shoshani, 1988 for a discussion).

Although most of the methods proposed to infer the age of extant elephants (particularly as regards to *Loxodonta*) are based on dental progression and wear (Johnson & Buss, 1965; Laws, 1966; Sikes, 1966, 1967; Lang, 1980; Lark, 1984; Roth, 1982; Jachmann, 1988; Roth & Shoshani, 1988; Lindeque, 1991), some alternative methods have been recently suggested. Accordingly, to infer the ages of the studied individuals, we also considered some recent ontogenetic studies made on African bush elephants (Lee *et al.*, 2012; Stansfield, 2015; Haynes, 2017). Combining different methods, we inferred the age at death for all the elephants herein studied. This was in order to compare the inferred age with the age known for some individuals.

The same approach was followed with regards to gender determination. To infer the gender, we followed the described dimorphic morphological traits (Todd, 2010) for *E. maximus* and personal observations for Africa and Asian (Sri Lanka) elephants.

3.2.4. IDENTIFICATION OF SAMPLES

Most of the specimens herein analysed lack labels and no information about their provenance, gender, and age at time of death is available. For some specimens, instead, their attribution to one or the other individuals was quite easy because their presence in the MCZR's collection and their previous history at the Giardino Zoologico have been well documented (cf. Gippoliti, 2014). In other cases, once the species/subspecies the specimens belong to was identified, the inferred age at death and sex were compared with the data available for each elephant individual that died in the ZGR during the last century, and for the few individuals whose cranial remains are known to have joined the MCZR's osteological collection from elsewhere. In some cases, the comparison allowed for the correct identification of the specimen. Some doubts, however, persisted about some cranial remains, hampering any firm reference to one or another elephant that died at the ZGR or whose remains were acquired by MCZR.

4. RESULTS

Based on the taxonomical and dimorphic distinctive characters described above, on dimensions (Tables 1, 2, 3) and the age inferred averaging the results obtained by means of different methodological approaches (Table 4), we are able to compellingly identify 4 Asian and 3 African among the 14 Asian and the 6 African elephants that died at the ZGR from 1910 to 2012 (Gippoliti, pers. data), while for 3 Asian elephants the identification was doubtful or highly uncertain (Table 5). In addition, we acknowledged the presence in the MCZR's osteological collection of a large skull and mandible of unknown provenance (MCZR OS.1302), and of the skull of an African male (MCZR OS.1307) from Gangala na Bodio (Congo RCD) that lived at the Zoo of Naples from 1952 to 1955 (see Appendix - Inventory Sheets 7a, 7b).

The main distinctive features of specimens can be summarized as follows.

Table 1 – Basic measurements (in mm) of the elephant skulls

ZB = Zigomathic breath; **BpOP** = Breath at the postorbital processes; **BpOC** = Breath at the postorbital constriction; **BTL** = Breath at the temporal lines; **OB** = Occipital breath; **mPB** = minimun Premaxillary breath; **MPB** = maximum premaxillary breath; **DI-P** = Inion-Prosthion distance; **MLS** = maximum skull length; **BL** = Basal length; **DI-N** = Inion-Nasion Distance: Occipital height (from Opisthion); **Ba-Oc** = Occipital hight (From Basion); **ExNarW** = Widh at the external naris; **m-d Wpx** = medio- distal width; **b-l WPx** = bucco-lingual width of the tusk alveolus

Species	Inventory number	ZB	BpOP	BpOC	BTL	OB	mPB	MPB	DI-P	MLS	BL	DI-N	OH	Ba-Oc	ExNarW	m-d WPx	b-l WPx
Loxodonta africana	MCZR Os.1302	951	798	444	444	864	472	748	668	1100	1039	473	555	636	453	171	162.5
Loxodonta africana	MCZR Os.1303	505	408	277	277	459	246	310	269	643	611	243	304	340	251	86	78
Loxodonta africana	MCZR Os.1311	–	–	–	–	–	–	–	–	–	–	–	–	–	–	90	–
Loxodonta cyclotis	MCZR Os.1307	–	438	284	284	488	252	332	265	588	632	265	305	369	272	60	83
Loxodonta cyclotis	MCZR Os.1308	415	303.5	228.7	228.7	355	184	255	–	–	–	–	–	–	–	–	–
Elephas maximus maximus	MCZR Os.1306	395	300	225	225	381	–	–	–	–	–	–	251	298	–	–	–
Elephas maximus maximus	MCZR Os.1312	222.2	121.4	127.6	162.5	176.8	87.3	77.2	102.1	278.7	267	201	–	–	54.2	21.4	16.3
Elephas maximus sumatranus	MCZR Os.1301	759	592	349	349	689	351	427	507	954	826	400	476	543	390	110	116
Elephas maximus (?sumatranus)	MCZR Os.1305	–	455	285	285	573	284	316	317	784	702	338	385	415	257	–	–
Elephas maximus	MCZR Os.1304	582	546	287	287	598	238	274	351	849	–	368	–	–	264	58	57
Elephas maximus	MCZR Os.1309	303.9	228.7	163.2	163.4	266	119.5	138	130	354	–	196.2	–	–	–	18	20

Table 2 – Basic measurements (in mm) of the elephant mandibles

ML = maximal length, **MW** = maximal widh at the hoizontal ramuses; **eDC** = external distance between condyluses; **m-lC** = medial-lateral breath of the right condylus; **a-pC** = antero-posterio depth of the right condylus; **LS** = Lenght of the synphysis; **DC-s** = Didtance between condilus and symphysis

Species	**Inventory number**	**ML**	**MW**	**eDC**	**m-lC**	**a-pC**	**LS**	**DC-S**
Loxodonta africana	MCZR Os.1302b	570	490	66.4	112	85	190	815
Loxodonta africana	MCZR Os.1303b	375	304	44	69	39	105	525
Loxodonta africana	MCZR Os.1311	–	–	–	–	78	159	700
Loxodonta africana	MCZR Os.1313	539	392	57.5	103	89	140	708
Loxodonta cyclotis	MCZR Os.1307b	360	326	46,4	58	43	113	540
Loxodonta cyclotis	MCZR Os.1308b	280	222	33	52	37	96	393
Elephas maximus maximus	MCZR Os.1306	320	250	37.4	73	54	105	458
Elephas maximus maximus	MCZR Os.1312	–	–	–	37.8	26.5	–	253.5
Elephas maximus maximus	MCZR Os.1310	122	122	c. 24.5	–	–	51.0	–
Elephas maximus	MCZR Os.1314	521	459	53.2	95	76	141	725
Elephas maximus	MCZR Os.1315	499	396	56.6	92	74	146	660
Elephas maximus	MCZR Os.1316	426	410	51.2	90	68	136	625

MCZR OS.1301

(Appendix - Inventory Sheet p. 43)

The skull is dorso-ventrally elongated, and, consequently, shows a long forehead, high maxillary region, and posterior-anteriorly downwards-inclined zygomatic arches, and a flat occipital. The nuchal fossa is oval in shape with marked muscle scars. The premaxillary bones are robust, dorsally moderately concave, and outward directed. The molariform teeth are quite wide with respect to their length. These features are all characteristic of *E. maximus sumatranus* male individuals. The ultimate molariform tooth is partially erupted, and only four plates were in use, suggesting an age at death of about 28-32 years (Figure 2).

This specimen could be identified as belonging to the elephant named Pluto (Figure 3), though there is a room of doubt due to the inconsistency between the age at death herein inferred and that deduced by historical data. The elephant, indeed, wild-born in Sumatra, was donated by the Circus Krone to the ZGR in 1924, at an alleged age of about 20 years, and died of cerebral congestion in 1927 (Gippoliti, pers. data). Consequently, the age at death, 23 years, would have been younger than that we have calculated. However, due to the uncertainty about the actual age at death of the elephant named Pluto, and the risk of some inaccuracies in estimating the age of captive elephants, although by applying robust methods based on tooth progression, the hypothesis that the skull may belong to Pluto seems to be quite reasonable.

MCZR OS.1302a, MCZR OS.1302b

(Appendix Inventory - Inventory Sheet pp. 44-45)

Skull and mandible of a very large *L. africana* male, showing all the morphological features typical of the species and the sex. To note the enormously developed lacrimal protuberances and the massive tusk sockets. The mandible has a robust and long symphyseal rostrum and large, spheroidal condyles, as it generally occurs in African bush elephant males. The alveolus of the penultimate molariform teeth is still present both in the skull and mandible. The ultimate teeth (M6, m6) are nearly completely erupted, and platelets are visible. Only the last plate of the right upper tooth is totally unworn. The inferred age at death is about 45 years. The dimensions fall within the range of very large males, posing an intriguing question about the origin of this cranium, apparently recovered in Rome from a public dump.

Table 3 – Measurements (in mm) of upper and lower molariform teeth

Pl tot = total number of plates; **AT** = anterior talon; **PT/Platelet** = posterior talon or platelet; **FPL** = number of plates in use; **W** = width; **WF** = occlusal width; **H** = height of crow; **HF** = maximal height from the occlusal surface to roots; **e-min** = minimum email thickness; **e-max** = maximum email thickness; **e** = average email thickness; **F occl** = lamellar frequency measured on the occlusal surface; **F med** = lamellar frequency measured on the medial surface; **F lat** = lamellar frequency measured on the lateral surface

Species	Identification number	Position	Side	Pl tot	AT	PT/ Platelet	FPl	L	LF	W	WF	H	HF	e-min	e-max	e	F occl	F med	F lat
Loxodonta africana	MCZR Os.1302a	M6	left	10	–	X	10	293.8 +	280.5	94.8	85.6	–	–	3.2	3.6	3.4	4	4	4
		M6	right	10	–	X	9	312.7	278.5	90.8	78.7	–	–	3.1	3.4	3.3	3.5	3.5	3.7
	MCZR Os.1302b	m6	left	8 +	–	X	8	243.7	>207	81.2	76.7	–	–	3.2	3.8	3.4	3.5	3.5	3.5
		m6	right	8 +	X	X	8	c. 215.5	>183	7.2	76	–	–	2.9	3.7	3.2	4	4	4
	MCZR Os.1303a	M3	left	5	–	–	5	>61.5	61.5	48.2	44.8	–	–	1.7	2	1.8	4.5	4.5	4.5
		M3	right	5	–	–	5	63.4	63.4	48.2	45.1	–	–	1.6	1.9	1.8	4.5	4.5	4.5
		M4	left	6	–	–	4	>120	76	51	46.5	–	–	1.6	2.3	2.0	4.5	3.5	4
		M4	right	6	?	–	4	>120	83	48.5	45.5	–	–	1.7	2.2	1.9	4	3	4
		M3+M4	left	–	–	–	–	–	138.5	–	–	–	–	–	–	–	–	–	–
		M3+M4	right	–	–	–	–	–	147.3	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1303b	m3	left	5	–	–	5	69.8	69.8	43	41.5	–	–	2	2.8	2,4	3	3	3
		m3	right	5	–	–	5	>62.5	>62.5	43.4	41.2	–	–	1.9	2.9	2.5	3.25	3	3+
		m4	left	7	X	X	5	>128	83.2	46.8	41.3	–	–	1.4	1.7	1.6	3	3.5	3
		m4	right	7	X	X	5	>126	79.3	45.5	41.8	–	–	1.6	1.9	1.7	4	3.5	3.5
		m3+m4	left	–	–	–	–	–	131	–	–	–	–	–	–	–	–	–	
		m3+m4	right	–	–	–	–	–	143	–	–	–	–	–	–	–	–	–	
	MCZR Os.1311	M5	left	?>5	–	?	5	>110	110	80	c. 75	–	–	–	–	–	–	–	–
	MCZR Os.1313	m5	left	10	–	–	10	212.7	–	79.2	73.3	–	–	2.5	3.9	3.2	4.5	4	4.5
		m5	right	10	–	–	10	214.5	214.5	80.5	73.5	–	–	2.9	3.8	3.2	5	4.5	4.5
		m6	left	>7	–	–	0	>138	–	>66.8	–	–	–	–	–	–	(6)	(6)	(6)
		m6	right	>7	–	–	3	>140	40.6	>71	c 47.3	–	–	–	–	–	(6)	(6)	(6)
		m5+m6	–	–	–	–	–	–	254.8	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1314	m5	right	9	X	X	8	212.5	170.4	70	56.3	125.6	120	1.8	2.9	2.1	5	4	4.5
Loxodonta cyclotis	MCZR Os.1307a	M4	left	8 +	X		8	144.8	144.8	72.2	61.4	–	–	1.5	2.1	2	5.5	5.5	5.5
		M4	right	8 +	X		8	157	157	69.3	60.5	–	–	1.5	2.2	2	5.5	5.5	5.5
		M5	left	8 +			2	>168	56	60.5	60	–	–	1.6?	2.5?	2.2?	3	6	6
		M5	rightt	8 +			1	>172	33	58.5	51.3	–	–	–	–	–	–	–	–
		M4+M5	left	–	–	–	–	–	206.5	–	–	–	–	–	–	–	–	–	–
		M4+M5	right	–	–	–	–	–	196.8	–	–	–	–	–	–	–	–	–	–

follows Table 3 – Measurements (in mm) of upper and lower molariform teeth

Species	Identification number	Position	Side	Pl tot	AT	PT/ Platelet	FPl	L	LF	W	WF	H	HF	e-min	e-max	e	F occl	F med	F lat
Loxodonta cyclotis	MCZR Os.1307b	m4	left	7	?		7	140	140	65.3	54.8	–	–	1.8	2.4	2.1	5	5	5
		m4	right	7	?		7	138	138	64	56	–	–	1.9	2.5	2.2	5	5	5
		m5	left	>8			4/5?	>135	c 85	64.6	57.1	–	–	2	2.1	2	3	3	3
		m5	right	>8			5	>135	c 98	61	58.1	–	–	–	–	–	3	3	3
		m4+m5	left	–	–	–	–	–	210.5	–	–	–	–	–	–	–	–	–	–
		m4+m5	right	–	–	–	–	–	222.5	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1308a	M3	left	7	X	X	6	c. 104 (–)	c. 80	38.5	28.6	–	–	–	–	c. 1.7	5.5	4	4
		M3	right	7	X	X	6	101	76.5	c. 36	28.5	–	–	–	–	1.8	5.5	4	4
		M4	left	>2	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–
		M4	right	>3	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1308b	m3	left	8	X	X	7	c. 107	85.5	35.5	28.7	–	–	c. 1.1	c. 1.6	c. 1.3	5	4.5	5
		m3	right	8	X	X	7	c. 102	84	35	c. 28	–	–	c. 1.2	c. 1.6	c. 1.5	5	4.5	5
		m4	left	>3	?	?	0	–	–	–	–	–	–	–	–	–	–	–	–
		m4	right	>4	?	?	0	–	–	–	–	–	–	–	–	–	–	–	–
Elephas maximus sumatranus	MCZR Os.1301	M5	left	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		M5	right	>9	–	X	>9	>141	>141	81.2	78.3	–	55.5	1.6	3	2.2	7	7	<7
		M6	left	>13	X	X	1	>350	?	86.1	37.5	–	–	–	–	–	–	6.5	6.5
		M6	right	>12	X	X	5	337	72.2	86.5	73.3	?	–	–	–	–	3.5	7	7
Elephas maximus	MCZR Os.1304	M6	left	22	X	?	2	c. 317	35.3	86	53.2	–	c. 142	–	–	–	–	?	?7
		M6	right	?	X	?X	1(2)	c. 311	29	87.9	43.6	–	>160	–	–	–	–	–	–
E.maximus sumatranus	MCZR Os.1305	M4	left	13	?	X	7	167.5	95.5	c. 67.8	c. 61	–	–	–	2.9	–	3.5	8	8
		M4	right	15	?	X	7	c. 162	c. 93	72.8	63	–	–	?	?	?	3.5	8	8
Elephas maximus	MCZR Os.1306a	M2	left	6 +	X	X	6	66.8	65	37.2	32	–	43.2	–	–	0.7	5.5	5.5	5.5
		M2	right	6	X	–	6	c. 62	59.5	41.5	35.8	–	30.8	–	–	0.8	6	7	8
		M3	left	13 (12?)	–	X	3	c. 115	c. 31	43.2	25.7	–	–	–	–	–	–	–	9.5
		M3	right	12	–	X	2+	c 115	c. 28	45.4	25.6	–	–	–	–	–	–	–	9.5
	MCZR Os.1306b	m2	left	9	X	?	9	73.2	73	c. 36	30.6	–	–	–	–	–	6	–	–
		m2	right	9	X	?	9	70	70	38.5	33.7	–	–	–	–	–	6.5	–	–
		m3	left	12	X	X	5 (?6)	c. 105	30.6	40	42	–	–	–	–	–	5.5	–	–
		m3	right	12	X	X	6 (?6)	c. 108	33.7	40.9	30.5	–	–	–	–	–	5.5	–	–

follows Table 3 – Measurements (in mm) of upper and lower molariform teeth

Species	Identification number	Position	Side	Pl tot	AT	PT/ Platelet	FPl	L	LF	W	WF	H	HF	e-min	e-max	e	F occl	F med	F lat
Elephas maximus	MCZR Os.1309	M2	left	5	X	X	5	>55.5	>55.5	c. 35	27.2	–	20	1.5	1.8	1.7	4.5	5	4
		M2	right	5	X	X	5	c. 68	>66	37.19	c. 26	–	31.8	1.4	1.7	1.6	5	5+	4.5
		M3	left	>7	?	?	0	>69.6	–	–	–	–	–	–	–	–	–	–	–
		M3	right	?	?	?	0	–	–	–	–	–	–	–	–	–	–	–	–
Elephas maximus maximus	MCZR Os.1310	m1	left	4	?	X	4	17.5	13	12.2	9.7	14.4	14.3	0.8	–	–	–	–	–
		m1	right	4	?	X	4	16.5	13	12.3	9.8	15.1	15.2	0.8	–	–	–	–	–
		m2	left	8	X	X	3	>67	19.5	>24	14.0	–	–	c. 0.8	–	–	7	–	–
		m2	right	7+	?	?	3	>60	19.0	>26	14.5	–	–	c. 0.8	–	–	7	–	–
	MCZR Os.1312a	M1	left	4	X	X	4	21.2	–	–	–	–	–	–	–	–	–	–	–
		M1	right	4	X	X	4	20.55	–	–	–	–	–	–	–	–	–	–	–
		M2	left	9?	?	?	0	?	–	–	–	–	–	–	–	–	–	–	–
		M2	right	7?	?	?	0	?	–	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1312b	m1	left	4	–	X	4	?	–	–	–	–	–	–	–	–	–	–	–
		m1	right	4	–	X	4	18.85	14.35	c. 13.2	?	?	?	–	–	–	–	–	–
		m2	left	7	–	?	0	>55	–	–	–	–	–	–	–	–	–	–	–
		m2	right	6 (7)	–	?	0	>55	–	–	–	–	–	–	–	–	–	–	–
Elephas maximus	MCZR Os.1315	m5	left	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		m5	right	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		m6	left	>13	?	–	4	>320	59	?39.5	–	–	–	–	–	–	–	7	7
		m6	right	>13	–	–	5	>311	c. 65.8	56.2	–	c. 148	1.3	2.2	2	–	3.5	–	–
	MCZR Os.1316	m4	left	14	X	X	14	c. 188	c. 83	57.3	–	–	–	–	–	–	9	8.5	8
		m4	right	13	X	X	13	c. 190	c. 175	–	c. 61	–	–	–	–	–	8	8	8
		m5	left	>(7)	–	–	–	>160	–	–	–	–	–	–	–	–	–	–	–
		m5	right	>(6)	–	–	–	>177	–	–	–	–	–	–	–	–	–	–	–
	MCZR Os.1317	m6	left	15+	X	?	8	>215	121	76.9	65.1	–	–	1.7	2.6	c. 2	3.5	7	7
		m6	right	14+	X	?	8	>210	110	83.4	c. 68.5	–	–	1.8	2.2	1.9	7.5	6.5	7.5

Table 4 – Known and inferred age at death and sex of the individuals to which the analised skulls and mandibles belong

Species	Specimen	Inventory number	House name	Sex		Age at the death	
				known	**inferred**	**known**	**inferred**
Loxodonta africana	skull and mandible	**MCZR Os.1302a,b**	–	unknown	male	unknown	42-46 years
Loxodonta africana	skull and mandible	**MCZR Os.1303a,b**	–	unknown	?female	unknown	12-14 years
Loxodonta. africana	skull and mandible	**MCZR Os.1311**	Toto	male	male	32 years	30-34 years
Loxodonta africana	mandible	**MCZR Os.1313**	Jumbo	male	male	29 years	26-30 years
Loxodonta cyclotis	skull and mandible	**MCZR Os.1307a,b**	Mukkei	male	male	unknown	18-22 years
Loxodonta. cyclotis	skull and mandible	**MCZR Os.1308a,b**	Ercolino	male	male	c. 3,5 years	3,5-4,5 years
Elephas maximus maximus	skull and mandible	**MCZR Os.1306**	Remo	male	male	2 years	c. 2 (1,5-2,5) years
Elephas maximus maximus	skull and mandible	**MCZR Os.1312**	unnamed, stillborn	female	not inferable	0	0
Elephas maximus maximus	mandible	**MCZR Os.1310**	Zuma	female	not inferable	4 months	c. 4-5 months
Elephas maximus sumatranus	skull	**MCZR Os.1301**	Pluto	male	male	23 years	28-32 years
Elephas maximus	skull	**MCZR Os.1305**	–	male	male	unknown	13-18 years
Elephas maximus	skull	**MCZR Os.1304**	–	unknown	?male	unknown	28-34 years
Elephas maximus	skull	**MCZR Os.1309**	–	unknown	male	unknown	<1 years
Elephas maximus	skull	**MCZR Os.1315**	–	unknown	male	unknown	c. 30 years
Elephas maximus	skull	**MCZR Os.1316**	–	unknown	male	unknown	13-18 years
Elephas maximus	skull	**MCZR Os.1317**	–	unknown	?female	unknown	37-40 years

Table 5 – Difese

Species	Inventory number	Side	L	Lc	Wa	Ha
Elephas maximus maximus	**MCZROPE12a**	left	10.9	–	8.0	–
		right	1.9	–	7.75	–
Loxodonta sp.	**MCZR Os. 1320**		71.5	71	6	7.1
Loxodonta sp.	**MCZR Os. 1321**		54	46.8	4.4	5.8
Loxodonta sp.	**MCZR Os. 1322A**		70.9	68.2	3.8	4.5
Loxodonta sp.	**MCZR Os. 1322B**		66.7	63.9	3.6	4.4
Loxodonta sp.	**MCZR Os. 1323**		88.2	79.3	4.2	4.9
Loxodonta sp.	**MCZR Os. 1324***	? left	72.8	63.5	4.2	5.2
Loxodonta sp.	**MCZR Os. 1325***	? right	66.2	55.5	4.5	6.5
Loxodonta sp.	**MCZR Os. 1326**		79	69	5.2	6.6
Loxodonta sp.	**MCZR Os. 1327B**		132.8	107	8.2	8.9
Loxodonta sp.	**MCZR Os. 1327A**		121.9	101.5	8.4	8.9
Loxodonta africana (? Toto)	**MCZR Os. 1329**		200.5	160	11.4	12.6
? *Loxodonta*	**MCZR Os. 1328**		200.5	160	11.4	12.6

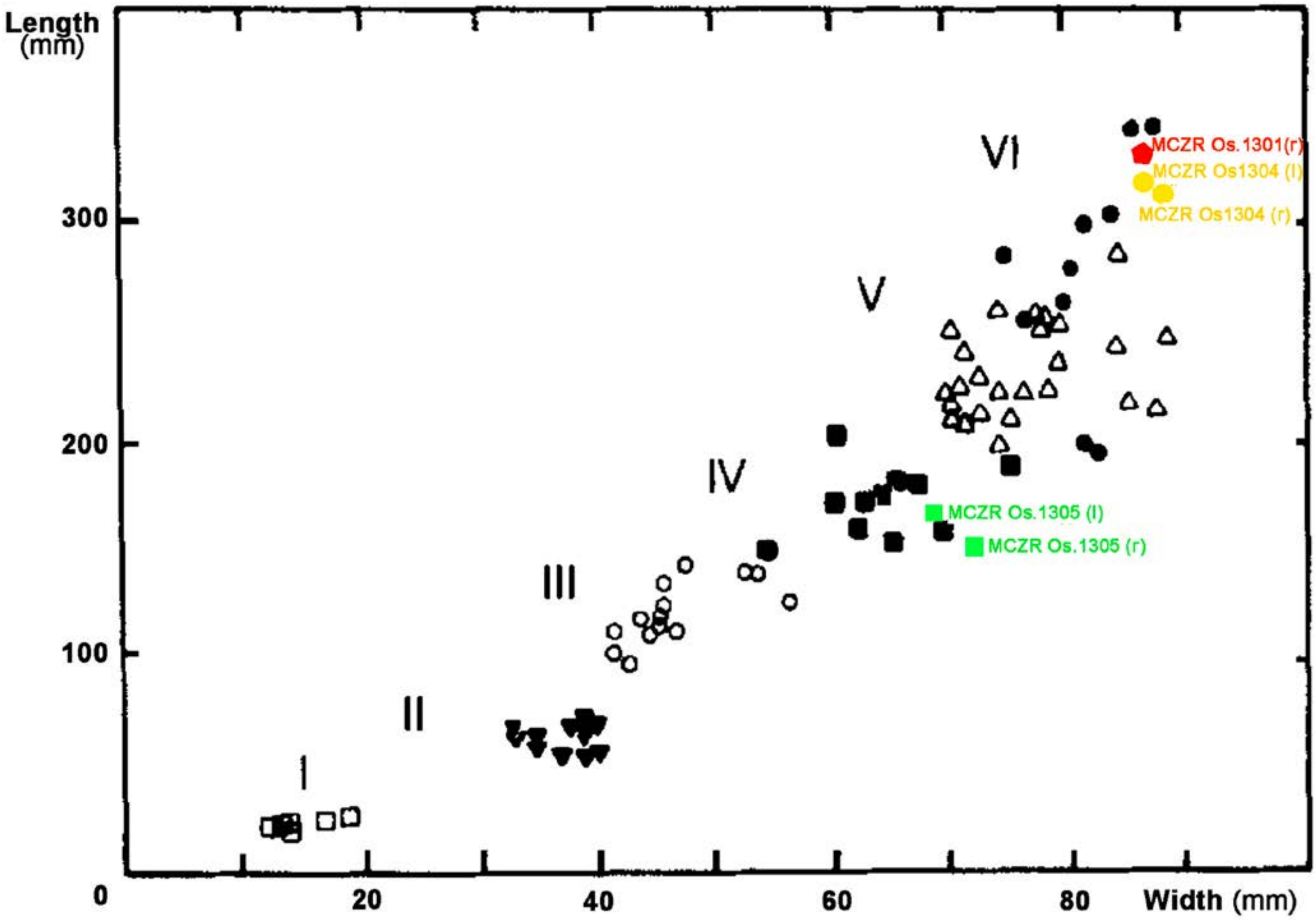

Fig. 2 – Scatter diagram of length vs. width of complete and nearly complete *Elephas maximus* upper teeth (modified from Roth and Shoshani, 1988, Fig. 3), showing the position of teeth present in the maxillary bones of MCZR Os.1301, MCZR OS. 1304, MCZR Os. 1305 specimens

MCZR OS.1303a, MCZR OS.1303b

(Appendix - Inventory Sheet pp. 46-47)

The overall shape of the skull and mandible (e.g. the lacrimal protuberance is present and the skull, seen in lateral view, shows a rounded cranial vault with a gently sloped occipital, a quite narrow forehead and nuchal fossa, and a slightly concave dorsal profile of the premaxillary bones, which are moderately curved distally) indicates the cranium belongs to a bush African elephant. The wear degree of the upper and lower second and third molariform teeth (M2/m2 and M3/m3) and the presence of an incipient opening of the m4 alveolus in the mandible suggest the age at death could have been about 12-14 years. Some morphological traits match those generally found in bush African elephant females (e.g. quite gracile mandibular symphysis, V-shaped nasal epiphyses, dumb-bell external choanae, and premaxillaries moderately expanse distally), but in the skull the region of the parietal-occipital crest is nearly flat. All in all, the inferred age (supported by the status of the unfused skull sutures and by the elongated mandibular shape) and a couple of morphological traits make it difficult to ascribe the cranial remains to one of the bush African elephants that lived at the ZGR. Among the females, the only putative candidate would be the Somalian elephant named Babar (Figure 4), but she was at least 17 years old when she died. Accordingly, the identification of the elephant to which the MCZR OS.1303 cranial remains belong remains unaddressed.

Fig. 3 – The Sumatran elephant Pluto at the ZGR (picture possibly taken in 1925)

Fig. 4 – The Somali elephant female Babar (right) with the male Jumbo (picture possibly taken in 1959)

MCZR OS.1304

(Appendix - Inventory Sheet p. 48)

The skull corresponds to an adult Asian elephant of about 28-34 years. Only the last molariform teeth, very hypsodont, only partially erupted and at a very incipient stage of wear, are present. The large alveoli of the penultimate teeth are partially ossified, suggesting they were lost when in use, possibly due to pathological conditions. Since the occipital bones are missing, the slope and the lateral profile of the frontal-occipital region, believed to distinguish the Sumatra subspecies, cannot be delineated.

The skull shows some intriguing features that make it challenging to infer the sex and, in turn, properly identify the individual to which it belongs. Although the quite small size (Table 1) may suggest a female, other morphological traits seem to fit better with a male. The skull shows, for instance, well developed parietal bosses, a parietal-occipital crest slightly concave in the median area, a narrow forehead, and the premaxillary bones, though not robust, are quite long weakly expanse distally (maximal breadth = 273,5 mm). The alveoli of the tusks, nearly rounded (breadth x height: right = 48.9 x 50.1 mm; left = la 52.5 x H 56.6 mm), are larger than usually found in Asian elephant females. To note, however, that the forehead is almost flat, the nasal bones are gracile, the external nares are dumb-bell shaped, and the incisive fossa is shallow and quite oval in shape, as it is more frequently found in females.

Hypothesising that the skull would belong to a female in spite of the presence of the small tusks, and assuming that the molariform teeth could actually be the ultimate ones (as dimensions and number of plates indicate, Table 3, Figure 2), the inferred ontogenetic age at death would indicate as the most suitable candidate among the elephant females that lived at the ZGR, the elephant named Giulietta (Figure 5) that died at the age of 35 years. The hypothesis has to be however rejected, not only because a number of skull features contradict any firm connection between the MCZR OS.1304 skull and this individual, but primarily because Giulietta was a tuskless female.

In addition, it does not seem possible to ascribe the MCZR OS.1304 skull to any other among the males that died at ZGR. Although the incomplete-

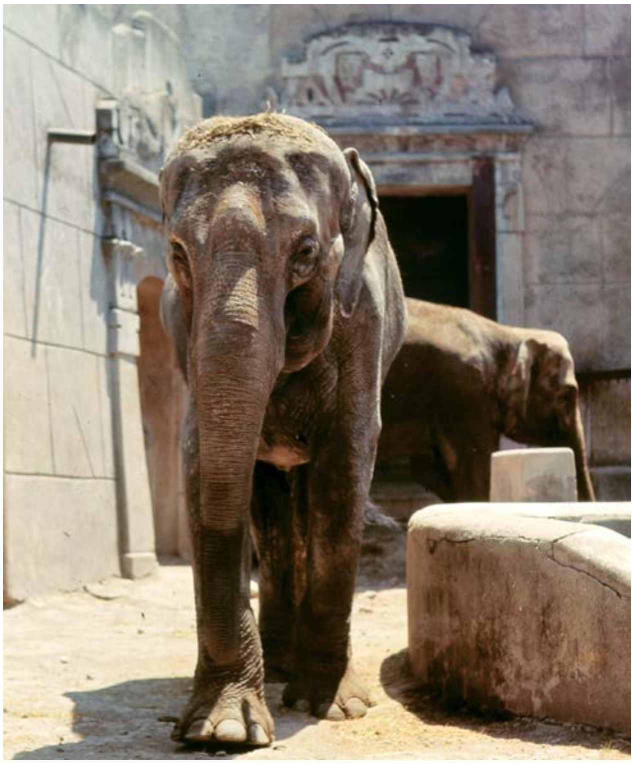

Fig. 5 – Female Ceylon elephant Giulietta II and behind her daughter Roma (picture possibly taken in 1957)

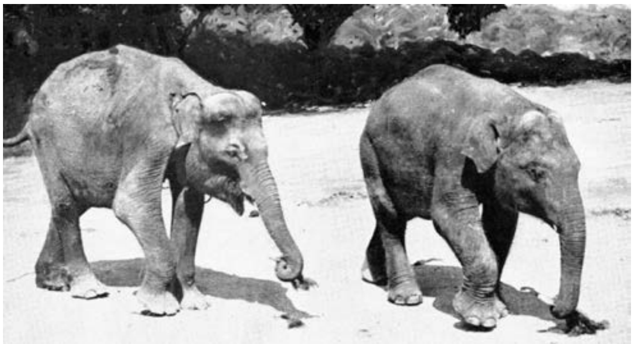

Fig. 6 – The Sumatran elephant Boby (right) just after his arrival at ZGR in 1929. The female Sandrina is on the left

ness of the occipital region prevents detection of some features alleged to differentiate *E. maximus sumatranus* (cf. Todd, 2010) (see discussion below), the inferred age would exclude the skull may be that of the Sumatra elephant named Boby, dead at the age of about 10 years, and the male named Romeo, dead at the age of 30 years, can be confidently excluded due to its large size.

MCZR OS.1305

(Appendix - Inventory Sheet p. 49)

In the skull MCZR OS.1305, only the M4 molariform teeth are in use. The penultimate teeth are nearly completely formed in the alveoli, but almost not erupted, being only 2 laminae detectable in the alveolus. The alveolus of M3 is nearly completely ossified. The inferred age of about 13-18 years may suggest that this could be the skull of the Sumatra elephant named Boby (Figure 6). The skull clearly belongs to a male, as supported, for instance by the quite massive premaxillaires distally expanded, the large tusk alveolus (width of the right alveolus of about 72 mm), but not all the morphological traits of the skull conform to those regarded as distinctive of the subspecies (cf. Todd, 2010), particularly as regards to height and curvature of the occipital region, and dorsal profile of premaxillary bones. It is important to note, however, that some characters regarded as taxonomically diagnostic show some variability (possibly related to ontogenetic age and sex), as suggested by a comparison among some *E. maximus sumatranus* skulls (Figure 7). Accordingly, the identification of MCZR OS.1305 remains probable, but not certain.

MCZR OS.1306

(Appendix - Inventory Sheet p. 50)

The skull and mandible of this young *E. m. maximus* are easily identifiable as belonging to the elephant named Remo (Figure 8), born at the ZGR in 1950 and dead two years later, and already described by Bronzini (Bronzini, 1975). In the skull, the nasal and premaxillary bones are missing, the right M2 and M3 are fused to each other, the alveolus of M4 is opening and two forming plates are detectable. The morphological characteristics are similar to those of Asian elephants, though the young age limits the possibility to detect features either diagnostic at subspecific level or useful to infer the sex. The presence in the mandible of a second molariform tooth with all the plates in use and of the third at an initial wearing stag suggests an age ranging from 1.5 to 2,5 years, in agreement with the known age at death.

MCZR OS.1307a and MCZR OS.1307b

(Appendix - Inventory Sheets pp. 52-53)

The morphological traits of both the skull and mandible (e.g. the lacrimal protuberance is absent, the cranial vault is almost flat with a quite steeply sloped occipital, the forehead is wide and long, the premaxillary bones are inferiorly directed with a nearly

Fig. 7 – Comparison of lateral views of *Elephas maximus sumatrensis* skulls housed at the National Museum Natural History, Washington D.C. (above) and three *E. maximus* skulls from the MCZR's osteological collection described herein (below). **A** = male NMNH 28237, modified from Todd (2010, Fig. 21); **B** = NMNH 240938 and **C** = NMNH 339499 modified from Shoshani and Eisenberg (1982, Fig. 3). Skulls are not in scale

straight dorsal outline, the incisive is rectangular, the mandibular symphysis is long and spout-like) indicate the cranium belongs to a bush African elephant. Some morphological traits match those generally found in bush African elephant males (e.g. quite long and massive mandibular symphysis, moderately concave dorsal profile of the skull, robust premaxillary bones with developed osteophytes). The wear degree of the upper and lower 4th and 5th molariform teeth suggests the age at death could have been about 18-22 years.

Consequently, the specimens could be identified as belonging to the forest African elephant named Mukkei (Figure 9), originated from Gangala na Bodio (Congo RCD), that lived from 1952 to 1955 at Giardino Zoologico of Naples, and whose skull and mandible were successively sent to MCZR in 1956 (Bronzini, 1957).

MCZR OS.1308a and **MCZR OS.1308b**
(Appendix - Inventory Sheets pp. 54-55)

The incomplete skull (occipital, pars lateralis and pars basalis, condyles, and nasal bones, are missing) and the mandible belong to a very young individual. The upper and lower 3rd molariform teeth are in use, the alveoli of the 4th are opening and 2 and 4 of the forming tooth are visible in the maxillary and mandible respectively, while the alveoli of the 2nd tooth are nearly completely ossified. The skull and mandible general shape (e.g. absence of lacrimal protuberance, position of coronoid apophysis, gently concave dorsal outline of skull, quite narrow forehead, slightly concave lateral outlines of premaxillary bones with incipient development of osteophytes, proportionally large alveoli of tusks) matches that of a young African forest elephant.

Fig. 8 – Remo, a newborn Asian elephant, with his sister Roma (August 1950)

The cranial remains can, therefore, be identified as belonging to the forest elephant male named Ercolino (Figure 10), received as a gift from the President of Gabon when the calf was six months old, and that died at the ZGR about three years later.

MCZR OS.1309

(Appendix - Inventory Sheet p. 51)

The incomplete skull (occipital, condyles, corpus of basisphenoid, and left premaxillary bones are missing, the zygomatic arches are incomplete) belongs to a very young individual. The M1 alveolus is still present, M2 are in use, and some plates, partially fused of M3 are visible in the alveoli. The preservation status does not permit verifying whether both M3 were partially erupted and in use or not, although the alveolus outline seems to suggest it. The premaxillary lateral profiles are parallel for most of their length. The lateral profile of the cranial vault is gently angulate, suggesting the skull may belong to a male individual. Unfortunately these characteristics do not match those of any skull of elephant individuals known to have lived at ZGR.

MCZR OS.1310

(Appendix - Inventory Sheet p. 56)

The mandible, with the first and second molariform teeth nearly unworn and the third still forming in the alveolus, clearly belongs to a very young Asian elephant, and can be confidently ascribed to the female named Zuma, born in captivity in the ZGR where she died at the age of four months.

MCZR OS.1311

The skull and the mandible belong to the well-known savannah African elephant male named Toto (Figure 11) (Gippoliti, 2014), whose skeleton, showing various pathologies, is displayed in the MCZR's "Skeleton Room", and will be described in depth elsewhere.

Fig. 9 – Mukkei and Barria, both forest African elephants, at Naples Zoo (1952, photo Richard Müller, courtesy U. Schürer)

MCZR OS.1312

The skull and the mandible belong to a *E. m. maximus* stillborn female (to note the presence of deciduous tusks) whose skeleton is displayed in the MCZR's "Skeleton Room" (Figure 12). The highly pathologically deformed skull will be described elsewhere.

MCZR OS.1313

(Appendix - Inventory Sheet p. 57)

The morphology of the mandible (particularly the length of the corpus, the symphysis shape, the position of the coronoid apophysis, the round, anteriorly oriented condyles, and the marked attachments of the lateral pterygoid muscle) indicate that it belongs to a bush African elephant male. The wear degree of molariform teeth (penultimate in use and partially erupted ultimate tooth with 2 plates slightly worn) indicates an age at death of about 26-30 years. Accordingly, the mandible likely belongs to the elephant named Jumbo, whose skull was dissected for anatomical studies and not preserved (Figure 4).

Fig. 10 – Young African male forest elephant Ercolino donated from the President of Gabon to Italy (1974)

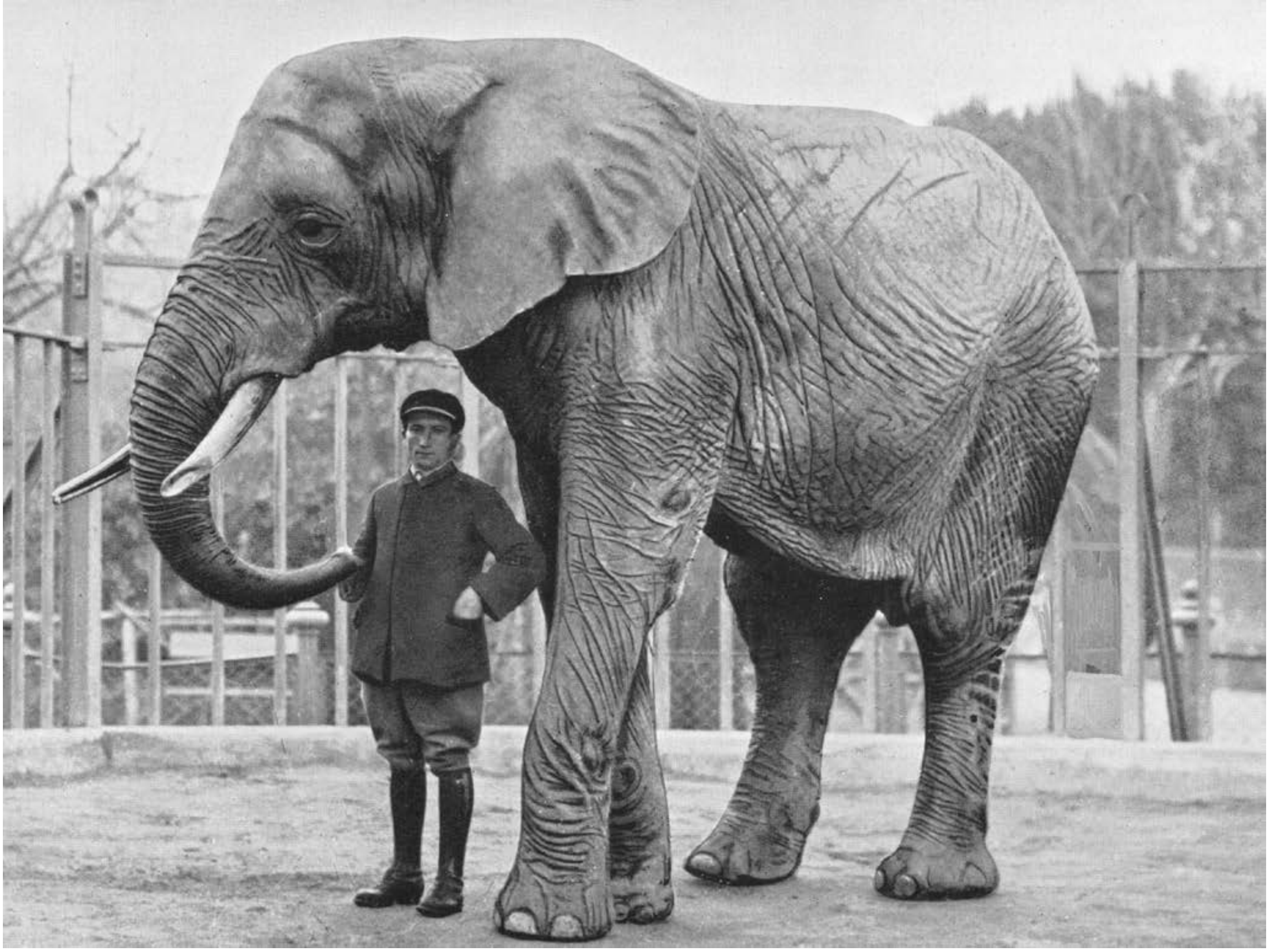

Fig. 11 – Adult male African bush elephant Toto with his keeper Ivo Calavalle (circa 1926)

Fig. 12 – Skeleton of an *Elephas maximus maximus* stillborn female mounted in the MCZR's "Skeleton Room", showing a highly pathologically deformed skull

MCZR OS.1315, MCZR OS.1316, MCZR OS.1317

(Appendix - Inventory Sheets pp. 58-60)

The three mandibles definitely belong to Asian elephants, as clearly indicated by the overall shape and by the dimensions, proportions, and characteristics of the enamel figures of molariform teeth, but it is challenging to ascribe them to one or the another among the skulls described above. This is because of the virtual absence of sexual dimorphic traits in the mandible of Asian elephants (except for the larger size and the more robust muscle markings that characterise males individuals with respect to females of the same age), and the substantial morphological similarity shown by Sumatran and other Asian elephant mandibles, exception given for the slightly proportionally high vertical ramus of some *E. m. sumatranus* mandibles.

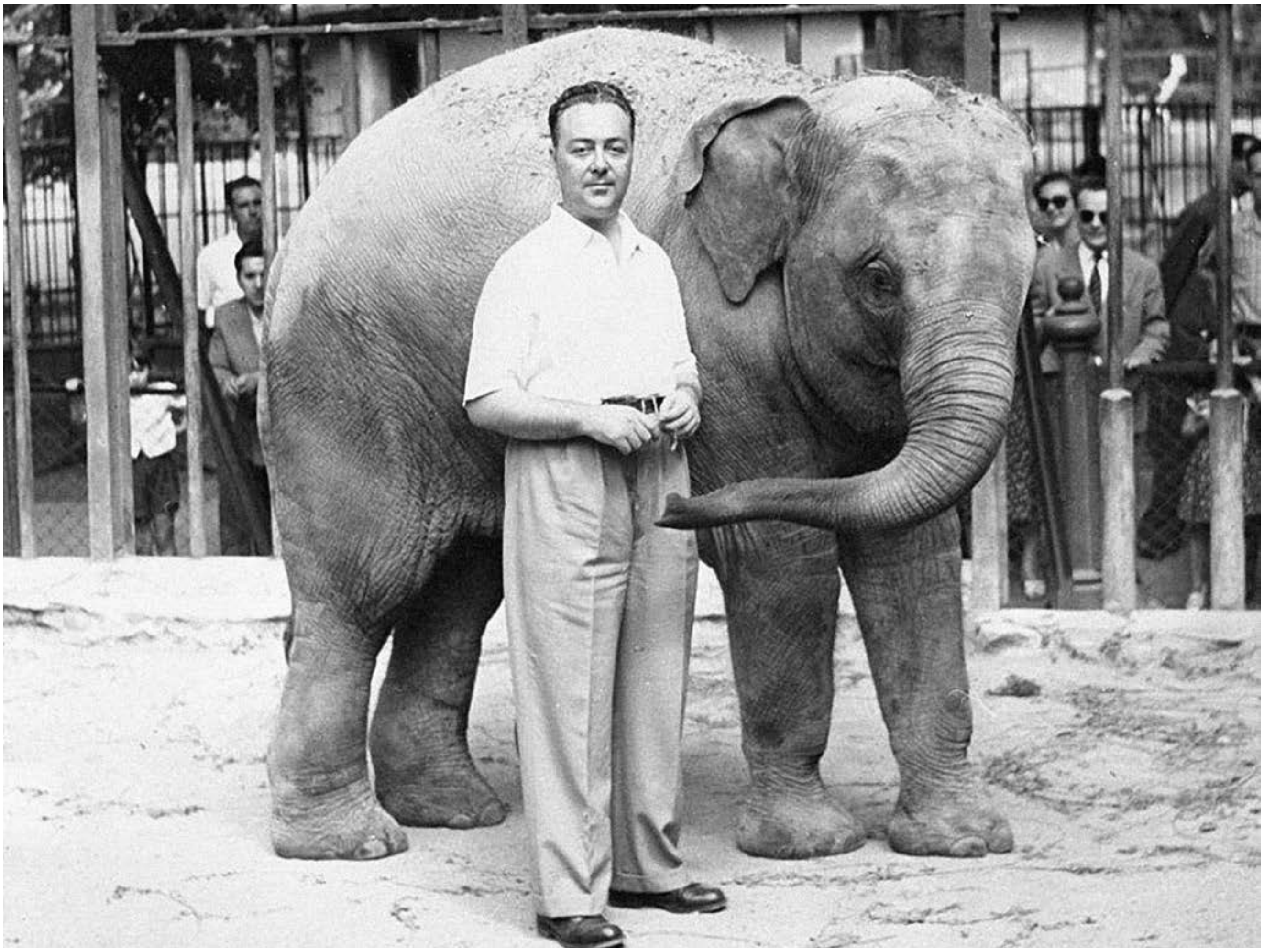

Fig. 13 – The Asian elephant female Roma at the age of three years, with Ermanno Bronzini (29 August 1952)

The **MCZR OS.1315** mandible, attributable to a male of about 30 years old, shows important pathological deformations, possibly related to persistent, highly invasive tooth abscesses. It seems, therefore, possible to hypothesise that the specimens belong to the same individual as MCZR OS.1301, whose left ultimate toot is characterised by an anomalous wear, suggesting the lack of the opponent tooth. More data is needed to support this hypothesis.

The **MCZR OS.1316** mandible also shows the effects of a pathological disease affecting the cartilage of mandibular condyles, which are anomalously globular. Taking into account the inferred age at death (13-18 years), the hypothesis that the mandible and skull MCZR OS.1305 may belong to the same individual cannot be discounted.

The **MCZR OS.1317** is quite small, not particularly massive. The alveolus of the penultimate tooth is partially ossified, in the ultimate molariform tooth, about 8 plates are in use, suggesting an age at death of about 37-40 (cf. Roth & Shoshani, 1988, Figure 7, Table 2). The evidence available does not support a convincing reference to the skull MCZR OS.1304.

5. REMARKS

In Italy, the link between Natural History Museums and zoos and other facilities keeping wild animals in captivity is not a new one, and this is particularly true for exotic species such as elephants.

The pivotal importance of natural history collections in studies dealing with a number of scientific questions, from taxonomy to biomechanics, histology, evolutionary biology, environmental monitoring, and zoo biology, is well established (Cotterill, 1997; Kitchener, 1997; Gippoliti & Kitchener, 2007; Gippoliti *et al.*, 2014; Lacey *et al.*, 2017). Some concern, however, arises about the observed decrease in institutional support to Natural History Museums, in Italy and a few other countries (Andreone *et al.*, 2014; Kryštufek, 2018). Considering the extent of the decline in the geographic range of recent elephant species, museum specimens may represent, in most cases, the only source of scientific data (genetic and morphological) on historically extirpated populations.

In Italy, extant African and Asian elephants are known to have lived in captivity in several zoos and travelling menageries, and their remains are present in different museums. We have already referred to the syntype of *E. maximus* in Florence. Between 1870 and 1873 (Anonymous, 1874), the Trieste Natural History Museum received a young African specimen, a taxon that was still relatively unknown in comparison to the Asian one at the time. It was a gift by Heirich Umlauff, brother-in-law of the famous animal trader Carl Hagenbeck, probably the remains of one elephant which died while en route from North East Africa to Hamburg. The Turin Zoological Museum received in 1876 from the Royal Zoological Garden in Turin (Camerano, 1881) the skeleton of a *L. africana* male captured in Sudan.

Although specimens of captive origin are frequently undervalued by museum curators, such specimens could be useful for testing the validity of age estimates provided by different methods, detecting some morphological changes due to captivity (see e.g. Robovský *et al.*, 2010), and assessing the range of dimensional and morphological individual variations. All this data could be useful if applied to analysing extinct species. The case of the MCZR's osteological collection is of particular interest because it preserves the remains of the four Asian elephants born between 1949-1955 in ZGR, the only elephants births occurred in Italy (Figure 12) (Anselmi & Calò, 1949; Crudi, 1951; Bronzini, 1975; D'Alessandro & Gippoliti, 1993).

Most of the greatest and medium-sized Italian natural history museums count in their collections at least one or two skulls of elephants, but their scientific value is often hampered by the lack of information about their geographic origin, sex, age etc. The absence of a technical staff and adequate space, moreover, may sometimes preclude the acquisition of new precious osteological material, although it would be relatively easily obtained from zoos (Gippoliti & Violani, 2009). It is worth noting, for instance, that the aged Asian individuals of wild origin still living in some zoos may represent the only survivors of extinct populations, and may represent the last sources of wild-born specimens possibly available as osteological material to natural history museums in Europe.

The contribution provided by integrated study of wid animal morphology, ethology and ecological behaviour, genetic, and by analysis of osteological material, indeed, may provide crucial clues to support taxonomical hypothesis.

It is, however, crucial that all the information concerning each specimen present in the museums' osteological collections be available (e.g., exact geographical origin of wild individuals, history, physical characteristic, age, body mass, height at the shoulders etc., at least at death of the captive individuals). As highlighted by our study, sometimes it may be a challenging task to determine with complete accuracy the age, sex, and even the subspecies of a skull or mandible if the morphological traits are inconsistent with each other or do not perfectly conform to the acknowledged diagnostic character of the focal taxon.

The more exhaustive the information accompanying each specimen, the more the data provided by the specimens of osteological collection can be an effective support in studies based on skeletal bones.

The analysis of the few skulls of African elephants of the MCZT's collection, for example, confirms the taxonomical significance of the differences already found between *L. africana* and *L. cyclotis.* A preliminary observation of a few *cyclotis*-like skulls in other Italian museums suggests that more attention should be paid to a qualitative study of specimens belonging to this taxon, especially as regards to dimorphic, ontogenetic, geographic, and individual variations.

As regards to *Elephas*, our study highlights the need to further scrutinize the morphological differences between *E. maximus maximus* and *E. maximus sumatranus*, and more clearly define the actual range of variation of the alleged taxonomical diagnostic features of the two subspecies. The morphological descriptive analysis, joined with genetic investigation, is crucial for lending support to a hypothetical division at the species level under the morphological and phylogenetic species concept, diagnosable version (cf. Groves *et al.*, 2017). More studies performed on rich samples are, indeed, necessary to quantify the intra-taxon morphological and dimensional variation ranges before revising the taxonomy of Asian elephants.

6. Conclusions

The critical revision of the elephant cranial remains present in the osteological collection of MCZR enables us to identify the skulls of two *L. cyclotis* males among the five African forest elephants known to have been held in captivity in Italy (Schürer, 2017). We identified one (maybe two) Sumatran elephant skull, possibly the sole present, at least in Italian natural history museums.

Interesting to note that most if not all these specimens were acquired in the period 1930-1965. The alternate vicissitudes successively undergone by MCZR (Carlini & Vomero, 2014), and the belief that there were already "enough" elephant specimens, are possibly some of the reasons why any acquisition ceased. The present study supports, instead, the evidence that the preservation of any skull of elephant's death in captivity, if accompanied by as much data as possible, may provide some clues crucial for disentangling still unclear matters related to extant and extinct proboscideans, such as the significance and extent of differences in morphology and proportions depending on ontogeny, dimorphism, the occurrence of ecomorphotypes or simple individual variability. Finally, it is worth noting that the Asian specimens of wild origin present in museum collections may represent the only survivors of extinct populations and, therefore, bear information no more otherwise available today.

Acknowledgements

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References

ALLEN G.M., 1936. Zoological results of the George Vanderbilt African expedition of 1934. Part II: The forest elephant of Africa. *Proceedings of the Academy of Natural Science Philadelphia*, 88: 15-44.

ANDREONE F., BARTOLOZZI L., BOANO G., BOERO F., BOLOGNA M., BON M., BRESSI N., CAPULA M., CASALE A., CASIRAGHI M., CHIOZZI G., DELFINO M., DORIA G., DURANTE A., FERRARI M., GIPPOLITI S., LANZINGER M., LATELLA L., MAIO N., MARANGONI C., MAZZOTTI S., MINELLI A., MUSCIO G., NICOLOSI P., PIEVANI T., RAZZETTI E., SABELLA G., VALLE M., VOMERO V. & ZILLI A., 2014. Italian natural history museums on the verge of collapse? *ZooKeys*, 456: 139-146.

ANONYMOUS, 1874. Civico Museo Ferdinando Massimiliano di Trieste. Continuazione dei cenni storici pubblicati nel 1869. Lloyd, Trieste.

ANSELMI S. & CALÒ A., 1949. Sul latte di elefante. *Rendiconti Istituto Superiore di Sanità*, 12: 372-381.

BAREJ M.F., SCHMITZ A., GUNTHER R., LOADER S.P., MAHLOW K., RÖDEL L., 2014. The first endemic West African vertebrate family – A new anuran family highlighting the uniqueness of the Upper Guinean biodiversity hotspot. *Frontiers in Zoology,* 11: 8.

BARNES R.F.W., CRAIG G.C., DUBLIN H.T., OVERTON G., SIMONS W. & THOULESS C.R., 1999. African elephant database 1998. IUCN Species Survival Commission Occ. paper 22. Gland, Switzerland: IUCN.

BARRIEL V., THUET E. & TASSY P., 1999. Molecular phylogeny of Elephantidae. Extreme divergence of the extant forest African elephant. *Comptes Rendus Acadêmiedes Sciences Paris Sciences de la Vie,* 322: 447-454.

BRONZINI E., 1957. Relazione sull'andamento del Giardino Zoologico di Roma durante l'anno 1956. *Zoo Bollettino dei Giardini Zoologicidi Milano e Torino*, 3: 1-11 (reprint).

BRONZINI E., 1975. Über das Zahnen, die Temperatur und das Wachstum in Gefangenschaft geborener asiatischen Elefanten (*Elephas maximus* L.). *Der Zoologische Garten*, 45: 97-128.

CAMERANO L., 1881. Ein Beitrag zur Anatomie des *Loxodon africanus. Zoologische Anzeiger,* 4: 481-483.

CAPPELLINI E., GENTRY A., PALKOPOULOU E., ISHIDA Y., CRAM D., ROOS A.M., WATSON M., JOHANSSON U.S., FERNHOLM B., AGNELLI P. & BARBAGLI F., 2014. Resolution of the type material of the Asian elephant, *Elephas maximus* Linnaeus, 1758 (Proboscidea, Elephantidae). *Zoological Journal of the Linnean Society*, 170 (1): 222-232.

CARLINI R. & VOMERO V., 2014. Cetacei e conservatori del Museo Civico di Zoologia di Roma: una tradizione storica italiana. *Memorie Museologia Scientifica*, 12: 279-308.

CARRUCCIO A., 1894. Osservazioni anatomiche sovra una testa ossea di giovanissimo *Elephas africanus. Bollettino della Società Romana di Studi Zoologici,* 3: 125-136.

CARRUCCIO A., 1913. *Taurotragus oryx* Pall. e sua armature scheletrica. Indicazione di scheletri completi e di crani importanti introdotti nella classe dei Mammiferi nel Museo della R. Università di Roma. *Bollettino della Società Zoologica Italiana*, (3)2: 77-83.

COTTERILL F.P.D., 1997. The second Alexandrian tragedy, and the fundamental relationship between biological collections and scientific knowledge. In: Nudds J.R., Pettitt C.W. (Editors). The value and valuation of natural science collections. Proceedings of the International Conference, Manchester, 1995. London, The Linnean Society of London: 227-241.

CRUDI L., 1951. Naissance et elevage d'un elephant asiatique au Jardine Zoologique de Rome. Minutes Meeting International Union of Directors of Zoological Gardens. 4 pp. Amsterdam 4-7 June.

CUVIER F., 1829. Dictionnaíre des sciences naturelles. Strasbourg e Paris, Lerrault.

D'ALESSANDRO A. & GIPPOLITI S., 1993. A list of wild mammals breeding at the Zoo of Rome from its foundation (1911) to 1991. *Hystrix Italian Journal of Mammalogy*, 4(2): 45-59.

DE BEAUX O., 1912. Über einige Saugetiere in Carl Hagenbeck's Tierpark in Stellingen. *Zoologische Anzeiger*, 39: 561-575.

DEBRUYNE R., VAN HOLT A., BARRIEL V. & TASSY P., 2003. Status of the so-called African pygmy elephant (*Loxodonta pumilio* (Noach 1906): phylogeny of cytochrome b and mitochondrial control region sequences. *Comptes Rendus Biologies*, 326: 687-697.

DERANIYAGALA P.E.P., 1955. Some Extinct Elephants, their Relatives and the two Living Species. Ceylon National Museum Publication, Colombo.

EGGERT L.S., RASNER C.A. & WOODRUFF D.S., 2002. The evolution and phylogeography of the African elephant inferred from mitochondrial DNA sequence and nuclear microsatellite markers. *Proceedings of the Royal Society London* B, 269: 1993-2006.

FERNANDO P., PFRENDER M.E., ENCALADA S.E. & LANDE R., 2000. Mitochondrial DNA variation, phylogeography and population structure of the Asian elephant. *Heredity*, 84: 362-372.

FERNANDO P., VIDYA T.N.C., PAYNE J., STUEWE M., DAVISON G., ALFRED R.J., ANDAU P., BOSI E., KILBOURN A. & MELNICK D.J., 2003. DNA Analysis indicates that Asian elephants are native to Borneo and are therefore a high priority for conservation. *PLoS Biology*, 1(1): e6.

FERRETTI M.P., 2008. The dwarf elephant *Palaeoloxodon mnaidriensis* from Puntali Cave, Carini (Sicily; late Middle Pleistocene): Anatomy, systematics and phylogenetic relationships. *Quaternary International*, 182(1): 90-108.

FERRETTI M.P. & DEBRUYNE R., 2011. Anatomy and phylogenetic value of the mandibular and coronoid canals and their associated foramina in proboscideans (Mammalia). *Zoological Journal of the Linnean Society,* 161: 391-413.

FRADE F., 1931. Sur l'existence en Afrique de deux espéces d'eléphants. *Bulletin de la Sociétè Portugaise Sciences Naturelles*, 11: 135-138.

FRADE F., 1933a. La mandibule des éléphants actuels. *Comptes rendues de L'Acadêmie des Anatomist*, Lisbonne, 6 pp.

FRADE F., 1933b. Les deux premiéres vertébres chez les éléphants d'Afrique. *Bulletin de la Sociétè Portugaise Sciences Naturelles*, 11: 277-287.

FRADE F., 1955. Ordre des proboscidiens (Proboscidea Illiger, 1811). In: Grassé P.P. (Editor), Traité de zoologie. Masson et Cie, Paris: 715-875.

GENTRY A., LISTER A.M., ROOS A.M., GILBERTM.T.P. & CAPPELLINI E., 2014. The lectotype for the Asian elephant, *Elephas maximus* Linnaeus, 1758 (Mammalia, Proboscidea) and comments on 'primary, secondary and tertiary syntypes' and 'virtual lectotype designation'. *Bulletin of Zoological Nomenclature*, 71(3): 208-213.

GIPPOLITI S., 2010: La giungla di Villa Borghese. I cento anni del Giardino Zoologico di Roma. Latina: Edizioni Belvedere.

GIPPOLITI S., 2014. One elephant, a museum specimen and two colonialisms: the history of M'Toto from German Tanganyika to Rome. *Museologia Scientifica,* NS, 8: 67-70.

GIPPOLITI S., AMORI G., CASTIGLIA R., COLANGELO P. & CAPANNA E., 2014. The relevance of Italian museum collection for research and conservation: the case of mammals. *Rendiconti Lincei Scienze Fisiche e Naturali,* 25: 351-357.

GIPPOLITI S. & BRUNER E., 2007. The role of historical research in the study of primatological collections: case studies from the Museo di Antropologia "G. Sergi", Rome. *Journal of Anthropological Sciences*, 85: 157-162.

GIPPOLITI S., LUPTAK P. & GROVES C.P., 2018. Flagship but only locally. The strange history of Bongo *Tragelaphus eurycerus* taxonomy. *Gazella* (Praha), 44: 48-60.

GIPPOLITI S. & KITCHENER A.C., 2007. The Italian zoological gardens and their role in mammal systematic studies, conservation biology and museum collections. *Hystrix Italian Journal of Mammalogy*, 18: 173-184.

GIPPOLITI S. & VIOLANI C., 2009. Collezioni animali viventi e collezioni museali in Italia: un'opportunità persa? *Memorie Museologia Scientifica*, 4: 131-136.

GROVES C.P., COTTERILL F.P.D., GIPPOLITI S., ROBOVSKÝ J., ROOS C., TAYLOR P.J. & ZINNER D., 2017. Species definitions and conservation: a review and case studies from African mammals. *Conservation Genetics*, 18: 1247-1256.

GRUBB P., GROVES C.P., DUDLEY J.P. & SHOSHANI J., 2000. Living African elephants belong to two species*:* *Loxodonta africana* (Blumenbach, 1797) and *Loxodonta cyclotis* (Matschie, 1900). *Elephant*, 2: 1-4.

GUGALA N.A., ISHIDA Y., GEORGIADIS N.J. & ROCA A.L., 2016. Development and characterization of microsatellite markers in the African forest elephant (*Loxodonta cyclotis*). *BMC research notes*, *9* (1): 364.

HAYNES G., 2017. Taphonomy of the Inglewood mammoth (*Mammuthus columbi*) (Maryland, USA): Green-bone fracturing of fossil bones. *Quaternary International*, 445: 171-183.

JACHMANN H., 1988. Estimating age in African elephants: a revision of Laws' molar evaluation technique. *African Journal of Ecology*, 26: 51-56.

JACHMANN H., BERRY P.S.M. & IMAE H., 1995. Tusklessness in African elephants: a future trend. *African Journal of Ecology*, 33 (3): 230-235.

JOHNSON O.W., BUSS I.O., 1965. Molariform teeth of male African elephants in relation to age, body dimensions, and growth. *Journal of Mammalogy*, 46: 373-384.

KITCHENER A.C., 1997. The role of museums and zoos in conservation biology. *International Zoo Yearbook*, 35: 325-336.

KNOTTNERUS-MEYER T., 1911. *Guida ufficiale del Giardino Zoologico di Roma*. SAIGA. Fratelli Armanino, Genova.

KNOTTNERUS-MEYER T. 1925. *Guida del Giardino Zoologico Comunale di Roma*. Giardino Zoologico Comunale di Roma.

KRYŠTUFEK B., 2018. Who cares about natural history collections? *Zoologicheskie Issledovania*, 20: 74-79.

LACEY E.A., HAMMOND T.T., WALSH R.E., BELL K.C., EDWARDS S.V., ELLWOOD E.R., GURALNICK R., ICKERTBOND S.M., MAST A.R., MCCORMACK J.E., MONFILS A.K., SOLTIS P.S., SOLTIS D.E. & COOK J.A., 2017. Climate change, collections and the classroom: using big data to tackle big problems. *Evo Edu Outreach,* 10: 2.

LANG E.M., 1980. Observations on growth and molar change in the African elephant. *African Journal of Ecology*, 18 (2-3): 217-234.

LARK R.M., 1984. A comparison between techniques for estimating the ages of African elephants (*Loxodonta africana*). *African Journal of Ecology*, 22 (1): 69-71.

LAWS R.M., 1966. Age criteria for the African elephant *Loxodonta a. africana*. *East African Wildlife Journal*, 4: 1-37.

LEE P.C., SAYIALEL S., LINDSAY W.K. & MOSS C.J., 2012. African elephant age determination from teeth: validation from known individuals. *African Journal of Ecology,* 50 (1): 9-20.

LINDEQUE M., 1991. Dentition and age estimation of elephants in the Etosha National Park, Namibia. *Madoqua*, 18 (1): 17-25.

LINNAEUS C., 1758. Systema naturae. Ed. 10. Salvius, Holmiae.

LISTER A.M., 1996. Evolution and taxonomy of Eurasian mammoths. The Proboscidea. Evolution and Palaeontology of Elephants and Their Relatives, Oxford, New York, Tokyo.

LISTER A.M. & VAN ESSEN H., 2003. Mammuthus rumanus (Stefanescu), the earliest mammoth in Europe. In: Petculescu A., Stiuca E. (Editors). Advances in Vertebrate Paleontology 'Hen to Panta'. Romanian Academy Institute of Speleology 'Emil Racovita', Bucharest: 47-52.

LYDDEKER R., 1907. The ears as a race character in the African elephant. *Proceedings Zoological Society London*, 1907: 380-403.

MAGLIO V.J., 1973. Origin and evolution of the Elephantidae. *Transactions of the American Philosophical Society*, 63 (3): 1-149.

MATSCHIE P., 1900. Über geographische Albarten des afrikanischen Elephanten. *Sitzungsberichte Gesellschaft Naturforschunde Freunde Berlin*, 8: 189-197.

MORRISON-SCOTT T.C.S., 1947. A revision of our knowledge of African elephants' teeth, with notes on forest and "pygmy" elephants. *Proceedings Zoological Society London,* 117: 505-527.

OWENS M.J. & OWENS D., 2009. Early age reproduction in female savanna elephants (*Loxodonta africana*) after severe poaching. *African Journalof Ecology*, 47 (2): 214-222.

PALKOPOULOU E., LIPSON M., MALLICK S., NIELSEN S., ROHLAND N., BALEKA S. ET AL., 2018. A comprehensive genomic history of extinct and living elephants. Proceedings of the National Academy of Sciences of the USA. https://doi.org/10.1073/pnas.1720554115.

RAUBENHEIMER E.J. & MINIGGIO H.D., 2016. Ivory Harvesting Pressure on the Genome of the African Elephant: A Phenotypic Shift to Tusklessness. *Head and Neck Pathology*, 10 (3): 332-335.

RAY J., 1693. Synopsis methodica animalium quadrupedum et serpentini generis. Smith & Walford, London, UK.

ROBOVSKÝ J., ANDĚRA M., & BENDA P., 2010. Revised catalogue of ceratomorph ungulates in the collection of the National Museum Prague and several other collections in the Czech Republic (Perissodactyla: Rhinocerotidae, Tapiridae). *Lynx*, 41: 237-294.

ROCA A.L., 2019. African elephant genetics: enigmas and anomalies. *Journal of Genetics*, 98 (3): 83.

ROCA A.L., GEORGIADIS N. & O'BRIEN S.J., 2005. Cytonuclear genomic dissociation in African elephant species. *Nature genetics*, 37 (1): 96.

ROCA A.L., GEORGIADIS N., PECON-SLATTERY J. & O'BRIEN S.J., 2001. Genetic evidence for two species of elephant in Africa. *Science*, 293: 1473-77.

ROTH V.L., 1992. Quantitative variation in elephant dentitions: implications for the delimitation of fossil species. *Paleobiology*, 18 (2): 184-202.

ROTH V.L. & SHOSHANI J., 1988. Dental identification and age determination in *Elephas maximus*. *Journal of Zoology*, 214: 567-588.

SANDERS W.J., 2018. Horizontal tooth displacement and premolar occurrence in elephants and other elephantiform proboscideans. *Historical Biology*, 30, 137-156.

SCHÜRER U., 2017. Über Waldelefanten. *Der Zoologische Garten,* NF, 86: 108-166.

SHOSHANI J. (consult. Ed.), 2000. Elephants (revised Edition). Checkmark Books (an imprint of Facts on File, Inc.), New York.

SHOSHANI J.& EISENBERG J.F., 1982. *Elephas maximus*. *Mammalian Species*, 182: 1-8.

SHOSHANI J. & TASSY P., 2005. Advances in proboscidean taxonomy & classification, anatomy & physiology, and ecology & behavior. *Quarternary International*, 126: 5-20.

SIKES S.K., 1966. The African elephant, *Loxodonta africana*: a field method for the estimation of age. *Journal of Zoology*, 150 (3): 279-295.

SIKES S.K., 1967. How to tell the age of an African elephant. *African Wildlife*, 21: 191-200.

STANSFIELD F.J., 2015. A novel objective method of estimating the age of mandibles from African elephants (*Loxodonta africana africana*). PloS ONE, 10 (5), p.e0124980.

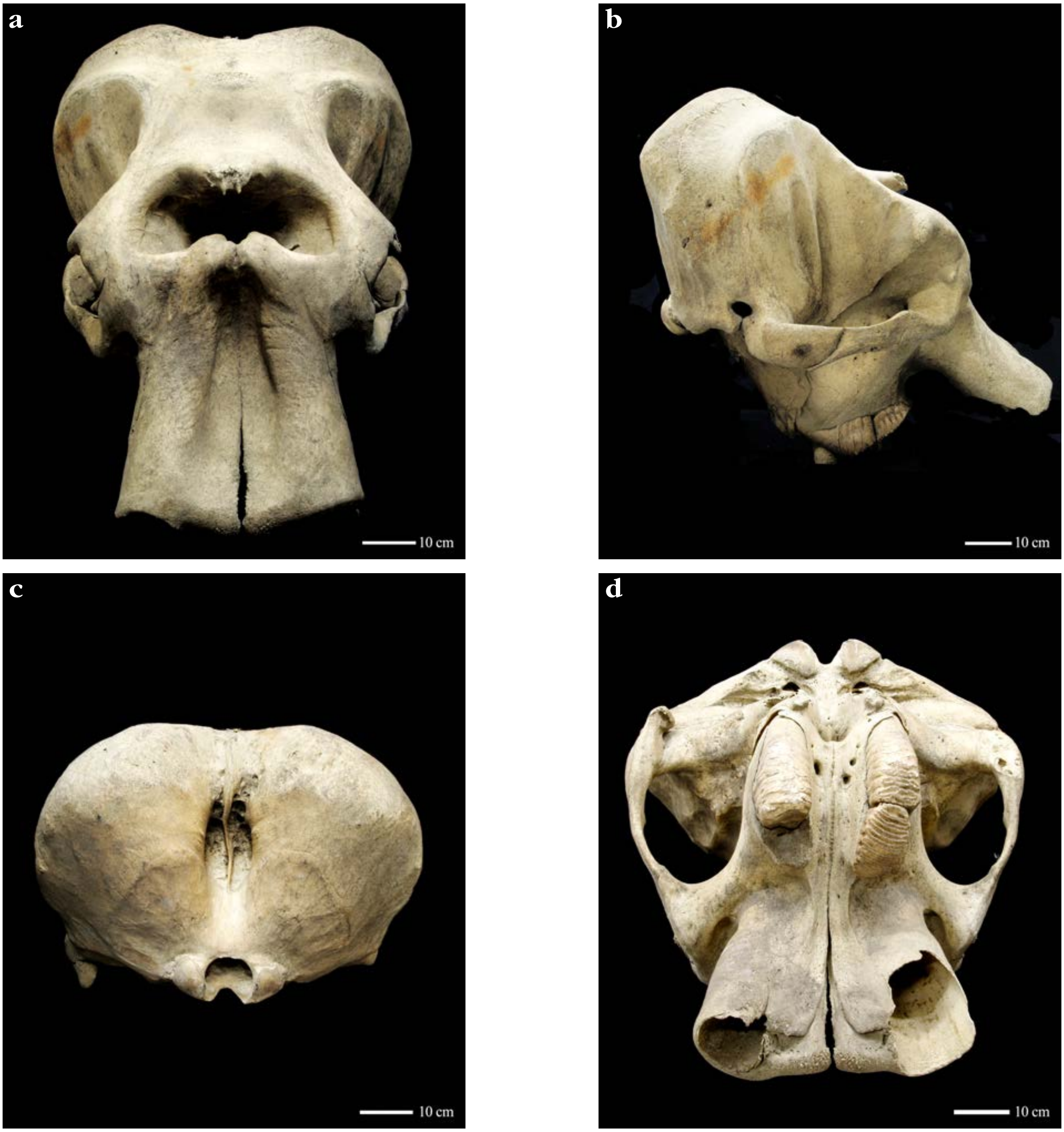
TODD N.E., 2010. Qualitative comparison of the craniodental osteology of the extant elephants, *Elephas maximus* (Asian elephant) and *Loxodonta africana* (African elephant). *Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology*, 293 (1): 62-73.

VIDYA T.N.C., FERNANDO P., MELNICK D.J. & SUKUMAR R., 2005. Population differentiation within and among Asian elephant (*Elephas maximus*) populations in Southern India. *Heredity*, 94: 71-80.

VOMERO V., 1988. Storia naturale di un museo di zoologia. L'Università di Roma e il Museo di via Aldrovandi. *Museologia Scientifica*, 5 (Supplemento): 177-202.

MCZR Os.1301 ***Elephas maximus sumatranus***

Specimen	skull	**Sex**	male
Provenance	ZGR	**Age at death**	circa 23 years (estimated)
Place of birth	Sumatra	**Date of birth**	unknown
Received from	Krone Circus	**Date of acquisition**	1923-1924
Place of death	ZGR	**Date of death**	1927



Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes This skull could be attributed to the Sumatra elephant male named Pluto, originally owned to the University collection

MCZR Os.1302S ex 6704 *Loxodonta africana*

Specimen	skull	**Sex**	male
Provenance	wild-born	**Age at death**	unknown
Place of birth	unknown	**Date of birth**	unknown
Received from	unknown	**Date of acquisition**	unknown
Place of death	unknown	**Date of death**	unknown

Skull in frontal (**a**), lateral (**b**), and ventral (**c**) view

Notes The skull and the mandible were apparently recovered from a dump in 1947

MCZR Os.1302M ex 6704 *Loxodonta africana*

Specimen	mandible	**Sex**	male
Provenance	wild-born	**Age at death**	unknown
Place of birth	unknown	**Date of birth**	unknown
Received from	unknown	**Date of acquisition**	unknown
Place of death	unknown	**Date of death**	unknown

Mandible in lateral (**a**) frontal (**b**), posterior (**c**), and dorsal (**d**) view

Notes The mandible and skull were apparently recovered from a dump in 1947

MCZR Os.1303S ***Loxodonta africana***

Specimen	skull	**Sex**	female
Provenance	wild-born	**Age at death**	about 17 years old
Place of birth	Somalia	**Date of birth**	unknown
Received from	ZGR	**Date of acquisition**	31.05.1955
Place of death	ZGR	**Date of death**	21.04.1970

Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes The skull is tentatively identified as that of the female named Babar

MCZR Os.1303M *Loxodonta africana*

Specimen	mandible	**Sex**	female
Provenance	wild-born	**Age at death**	about 17 years
Place of birth	Somalia	**Date of birth**	about 1953
Received from	ZGR	**Date of acquisition**	31.05.1955 at ZGR
Place of death	ZGR	**Date of death**	24.04.1970

Mandible in lateral (**a**) frontal (**b**), posterior (**c**), and dorsal (**d**) view

Notes The mandible is tentatively identified as that of the female named Babar

MCZR Os.1304 *Elephas maximus*

Specimen	skull	**Sex**	male
Provenance	wild-born	**Age at death**	unknown
Place of birth	unknown	**Date of birth**	unknown
Received from	unknown	**Date of acquisition**	unknown
Place of death	?ZGR	**Date of death**	unknown

Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes	Any identification of the skull with one of the Asian elephant males who lived at the ZGR would be highly speculative

MCZR Os.1305 *Elephas maximus*

Specimen	skull	**Sex**	male
Provenance	unknown	**Age at death**	13-18 years (inferred)
Place of birth	unknown	**Date of birth**	unknown
Received from	unknown	**Date of acquisition**	unknown
Place of death	?ZGR	**Date of death**	unknown

Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes	Any identification of the skull with one of the Asian elephant males who lived at the ZGR would be highly speculative

MCZR Os. 1306S,M ***Elephas maximus maximus***

Specimen	skull and mandible	**Sex**	male
Provenance	born in captivity	**Age at death**	2 years, 5 months
Place of birth	ZGR	**Date of birth**	02.09.1950
Received from	ZGR	**Date of acquisition**	02.09.1950
Place of death	ZGR	**Date of death**	24.12.1952

Skull and mandible in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes	House name Remo. Sired by Romeo II and Giulietta II, both living at ZGR. The cranial remains were studied by Bronzini (1975)

MCZR Os.1309 ***Elephas maximus***

Specimen	skull	**Sex**	female
Provenance	wild-born	**Age at death**	8 years
Place of birth	unknown	**Date of birth**	unknown
Received from	ZGR	**Date of acquisition**	12.05.1929 at ZGR
Place of death	ZGR	**Date of death**	05.07.1935

Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes The identification of the skull as belonging to young female named Sandrina is tentative

MCZR Os.1307S ***Loxodonta cyclotis***

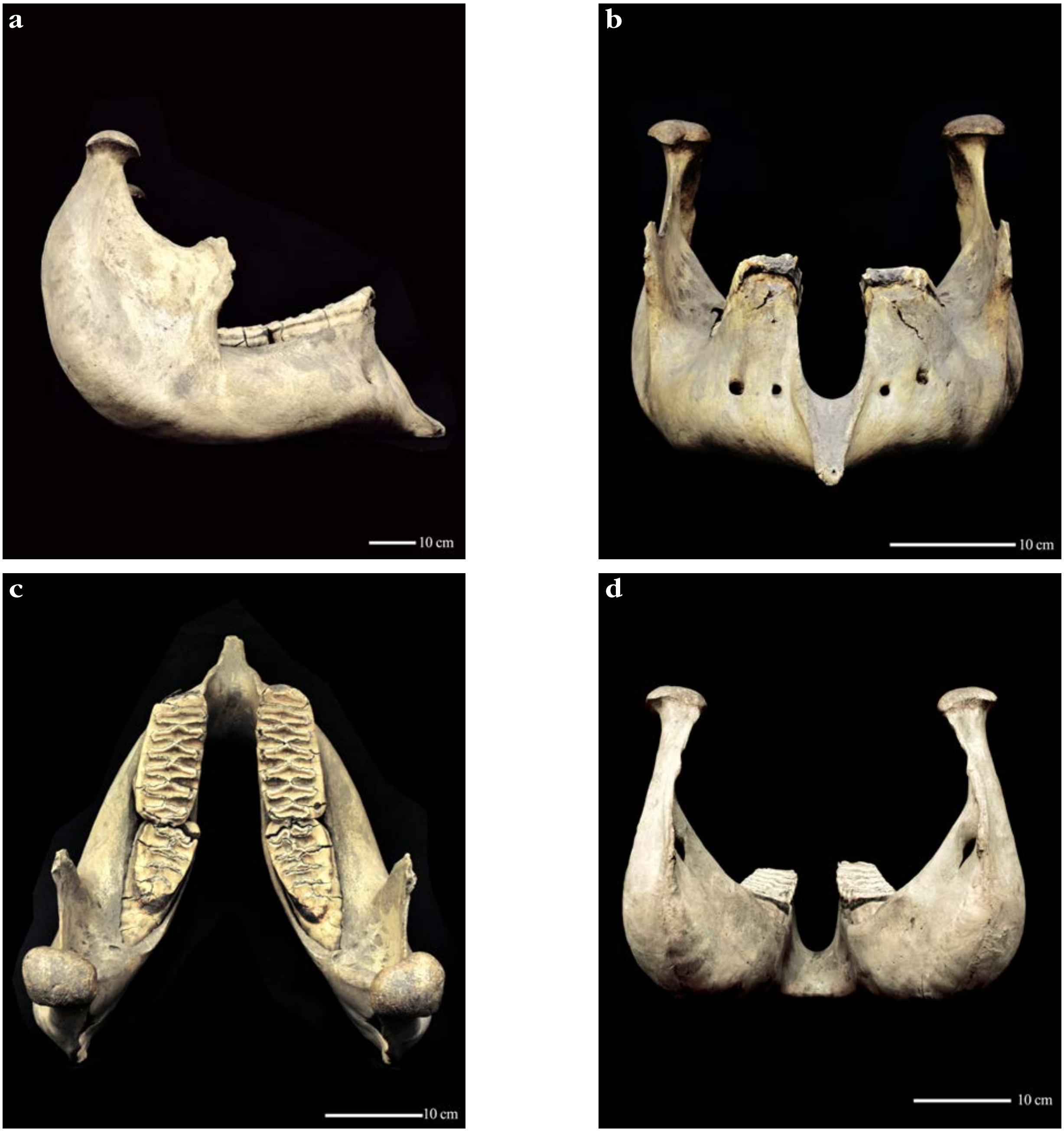
Specimen	skull	**Sex**	male
Provenance	Gangala na Bodio, DRC	**Age at death**	unknown
Place of birth	Congo DRC	**Date of birth**	unknown
Received from	Naples Zoo	**Date of acquisition**	1952
Place of death	Naples Zoo	**Date of death**	04.01.1955

Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes	Housename Mukkei received at the Zoological Garden in Naples on 28.5.1952 together with another young bull

MCZR Os.1307M *Loxodonta cyclotis*

Specimen	mandible	**Sex**	male
Provenance	Gangala na Bodio, DRC	**Age at death**	unknown
Place of birth	Congo DRC	**Date of birth**	unknown
Received from	Naples Zoo	**Date of acquisition**	1952
Place of death	Naples Zoo	**Date of death**	1955

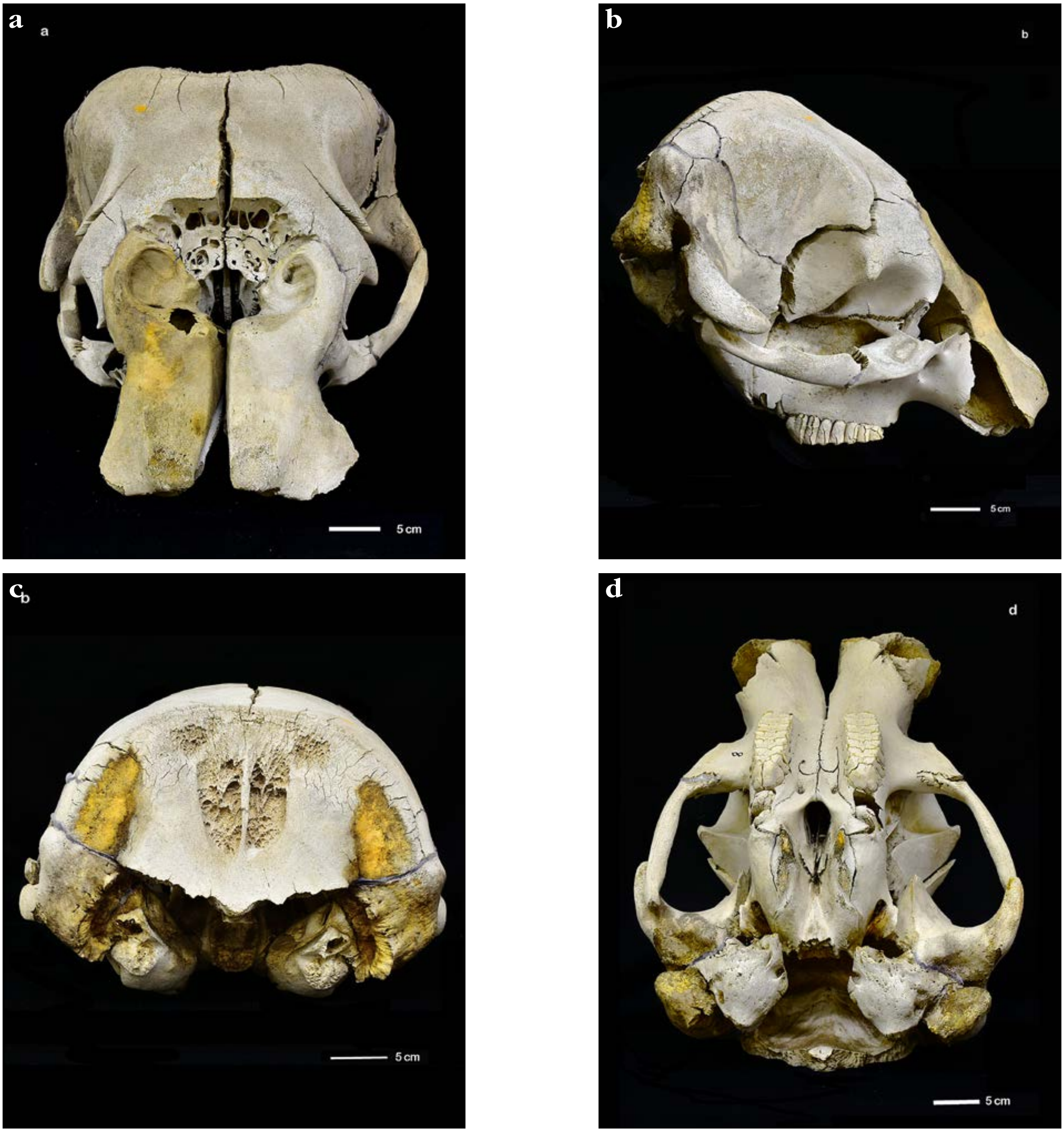


Mandible in lateral (**a**) frontal (**b**), dorsal (**c**), and posterior (**d**) view

Notes Housename Mukkei received by Zoological Garden in Naples on 28.5.1952 together with another young bull

MCZR Os.1308S ***Loxodonta cyclotis***

Specimen	skull	**Sex**	male
Provenance	wild-born	**Age at death**	about 4 years
Place of birth	Gabon	**Date of birth**	1973
Received from	ZGR	**Date of acquisition**	20.11.1973 at ZGR
Place of death	ZGR	**Date of death**	24.12.1976



Skull in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes Mandible of the forest African elephant calf named Ercolino

MCZR Os.1308M *Loxodonta cyclotis*

Specimen	mandible	**Sex**	male
Provenance	wild-born	**Age at death**	about 4 years
Place of birth	Gabon	**Date of birth**	1973
Received from	ZGR	**Date of acquisition**	20.11.1973 at ZGR
Place of death	ZGR	**Date of death**	24.12.1976

Mandible in lateral (**a**) frontal (**b**), posterior (**c**), and dorsal (**d**) view

Notes Mandible of the forest African elephant calf named Ercolino

MCZR Os.1310 ***Elephas maximus maximus***

Specimen	mandible	**Sex**	female
Provenance	captive - bred	**Age at death**	4 months
Place of birth	ZGR	**Date of birth**	30.07.1955
Received from	ZGR	**Date of acquisition**	unknown
Place of death	ZGR	**Date of death**	03.12.1955

Mandible in lateral (**a**) frontal (**b**), posterior (**c**), and dorsal (**d**) view

Notes Mandible of the Asian elephant calf female named Zuma

MCZR Os.1313 *Loxodonta africana*

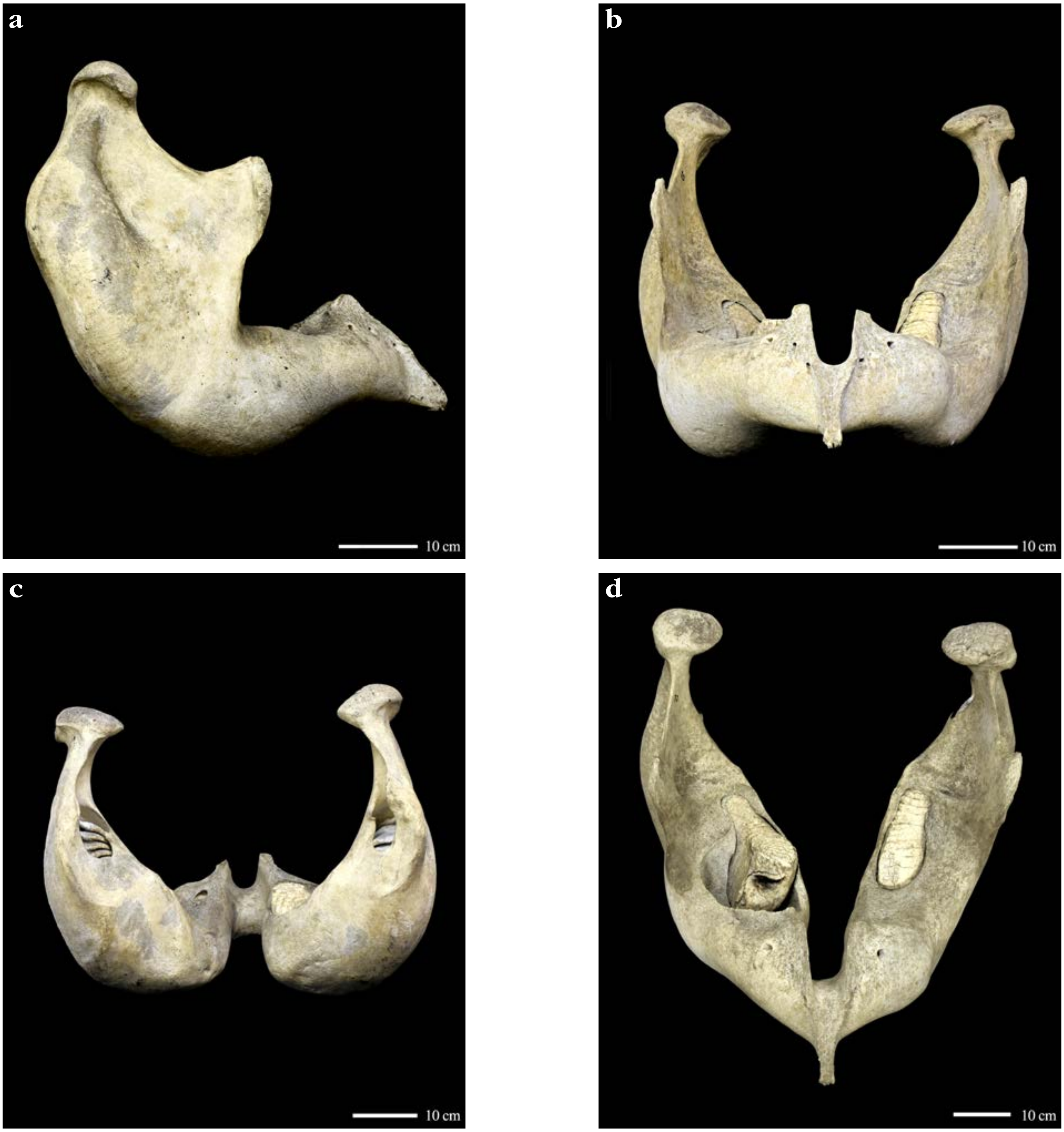
Specimen	mandible	**Sex**	male
Provenance	wild-born	**Age at death**	29 years (estimated)
Place of birth	Congo DRC	**Date of birth**	about 1950
Received from	ZGR	**Date of acquisition**	20.09.1956 at ZGR
Place of death	ZGR	**Date of death**	06.10.1979

Mandible in lateral (**a**) frontal (**b**), posterior (**c**), and dorsal (**d**) view

Notes Housename Jumbo. The skull was sectioned in an attempt to recover the brain, but it was unsuccessful (Giorgio Busacchi pers. comm.). Around 1955, Jumbo arrived from Gangala na Bodio at the Giardino Zoologico in Naples. Elephants of both species *L. cyclotis* and *L. africana* came from Gangala na Bodio

MCZR Os.1315 ***Elephas maximus sumatranus***

Specimen	mandible	**Sex**	male
Provenance	ZGR	**Age at death**	23 years (estimated)
Place of birth	Sumatra	**Date of birth**	unknown
Received from	Krone Circus	**Date of acquisition**	1923-1924
Place of death	ZGR	**Date of death**	15.07.1927



Skull and mandible in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes The identification of this mandible with those of Pluto (OS 1301) seems almost certain

MCZR Os.1316 ***Elephas maximus (?sumatranus)***

Specimen	mandible	**Sex**	male
Provenance	wild-born	**Age at death**	about 13-18 years
Place of birth	unknown	**Date of birth**	unknown
Received from	ZGR	**Date of acquisition**	unknown
Place of death	ZGR	**Date of death**	unknown

Skull and mandible in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes The mandible is tentatively associated to skull (OS 1305)

MCZR Os.1317 M *Elephas maximus*

Specimen	mandible	**Sex**	? female
Provenance	wild-born	**Age at death**	about 37-40 years
Place of birth	unknown	**Date of birth**	unknown
Received from	ZGR	**Date of acquisition**	unknown
Place of death	ZGR	**Date of death**	unknown

Skull and mandible in frontal (**a**), lateral (**b**), posterior (**c**), and ventral (**d**) view

Notes The mandible could be tentatively attributed to the female Giulietta II

INDICE

NORME REDAZIONALI

Il Bollettino del Museo Civico di Storia Naturale di Verona esce annualmente in due distinte sezioni: 1. Botanica e Zoologia; 2. Geologia, Paleontologia e Preistoria, e pubblica sia estesi contributi sia brevi note riguardanti gli aspetti naturalistici di tali discipline.

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I lavori devono essere indirizzati alla Redazione Editoriale - Museo Civico di Storia Naturale di Verona Lungadige Porta Vittoria, 9 37129 Verona, accompagnati da indirizzo, recapito telefonico ed eventuali fax e casella di posta elettronica dell'autore o, in caso di più autori, di un autore di riferimento. I contributi ricevuti dalla Redazione saranno inviati per una valutazione a revisori scientifici e quindi, se accettati, verranno rinviati agli autori con richiesta di eventuali modifiche. L'accettazione o il rifiuto dei lavori è in ogni caso di competenza della Redazione.

NORME DA SEGUIRE NELLA STESURA DEI TESTI

I contributi devono essere presentati su supporto informatico e in due copie stampate, con tavole e illustrazioni anche in fotocopia. Il lavoro dovrà essere accompagnato da un Abstract in inglese (comprensivo del titolo e di Key Words in numero non inferiore a 3) e da un Riassunto in italiano (comprensivo di Parole Chiave in numero non inferiore a 3). Abstract e Riassunto dovranno essere di almeno tre righe.

Intestazione: Titolo del lavoro in grassetto, nome e cognome (per esteso) dell'autore o degli autori in maiuscolo, Ente o Istituto di appartenenza oppure città di residenza degli autori in corsivo e tra parentesi, esempio: **Indagini idrogeologiche nell'area del Corno d'Aquilio (Monti Lessini nordoccidentali - Verona)**
ROBERTO ZORZIN
(Museo Civico di Storia Naturale di Verona)

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