



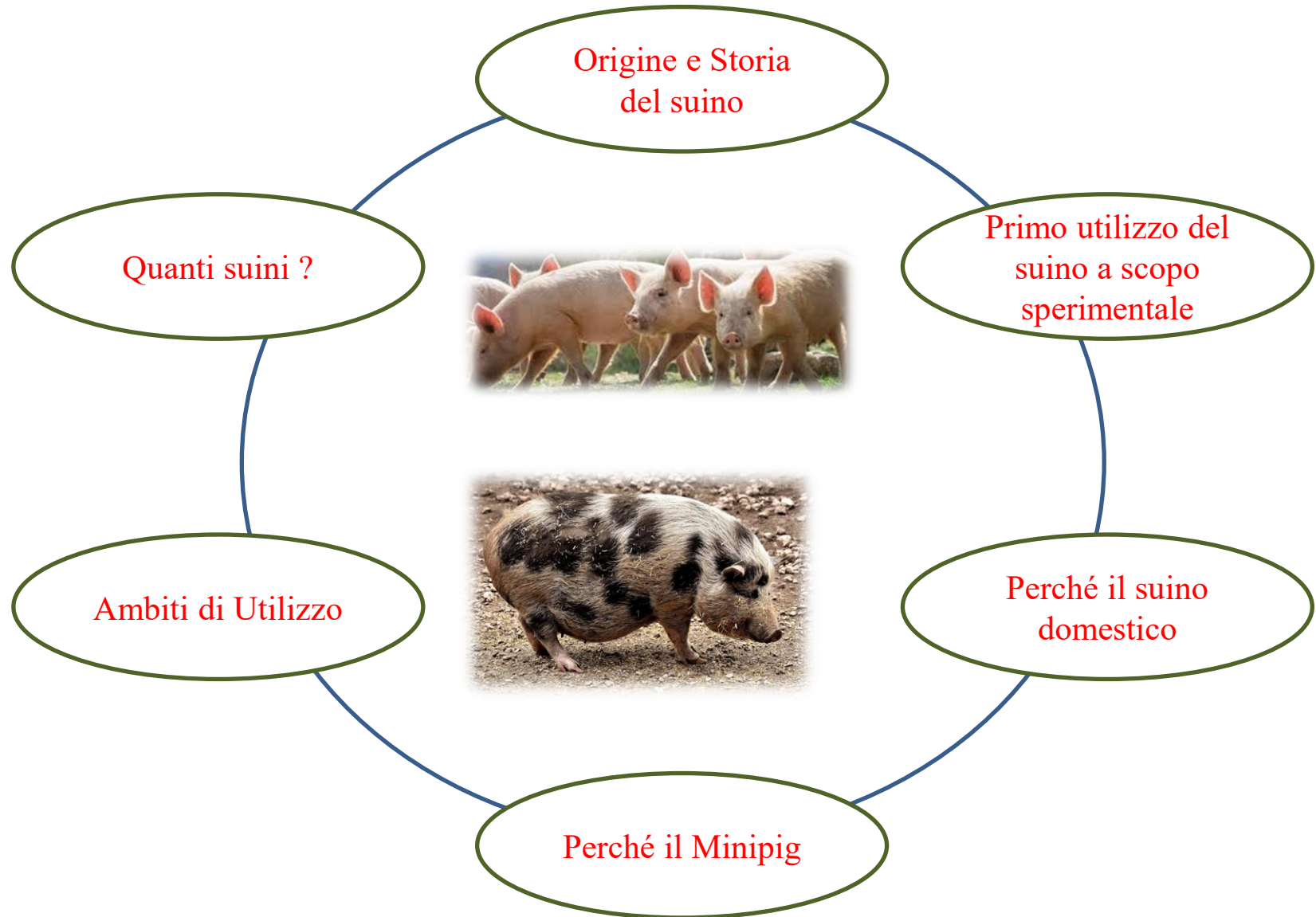
UNIVERSITÀ DI PISA



«Il mini pig come modello sperimentale»

Dott.ssa Silvia Burchielli MVD
Fondazione Toscana G. Monasterio
RBA Centro di Biomedicina Sperimentale

Il mini pig come modello sperimentale



Origini e Storia del Suino

Da un punto di vista evolutivo il primo antenato del maiale domestico sarebbe vissuto nel sud-est asiatico tra i 5 e i 3 milioni di anni fa, per estendersi nelle regioni euroasiatiche.

Le prime tracce nella storia del maiale risalgono al 40000 AC e sono state ritrovate nei pittogrammi rupestri delle grotte di Altamira in Spagna, e nell'attuale Zambia.

Una prima vera domesticazione del maiale si sarebbe avuta, invece, intorno al 5.000 AC ad opera delle popolazioni Cinesi.

L'allevamento del maiale è ritenuto il più antico per la sua propensione a mangiare qualsiasi cosa ed ad aumentare velocemente di peso



Origini e Storia del Suino

Nell'immaginario collettivo il suino è sia metafora di disprezzo e bestialità che vittima sacrificale e benefattore.

L'eccezionale importanza dell'allevamento del maiale nel Medioevo è dimostrata dagli statuti che regolavano la figura giuridica del porcaro considerata prevalente e tutelata tanto che la sua uccisione o il suo ferimento comportava pene e ammende ben superiori rispetto ad altri lavoranti.

Nell'antico Egitto i porcari non potevano entrare nei templi e potevano sposarsi solo tra loro, come una casta esclusa e reietta.

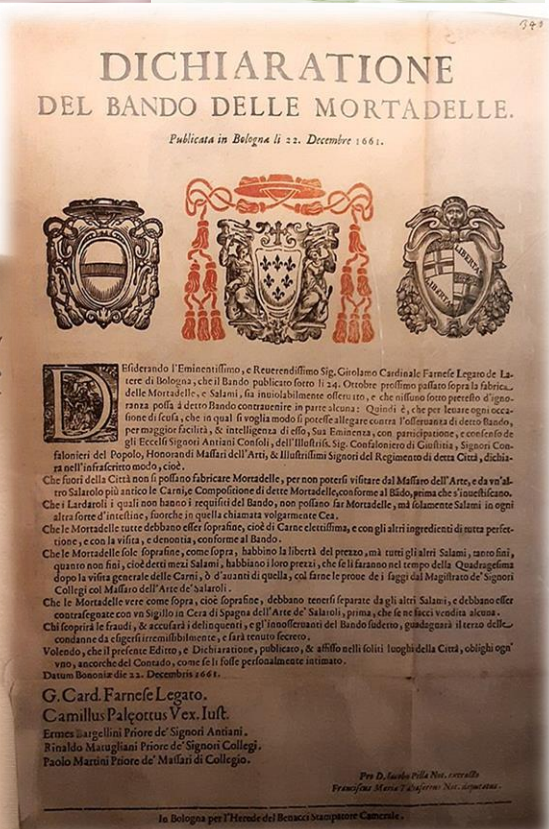
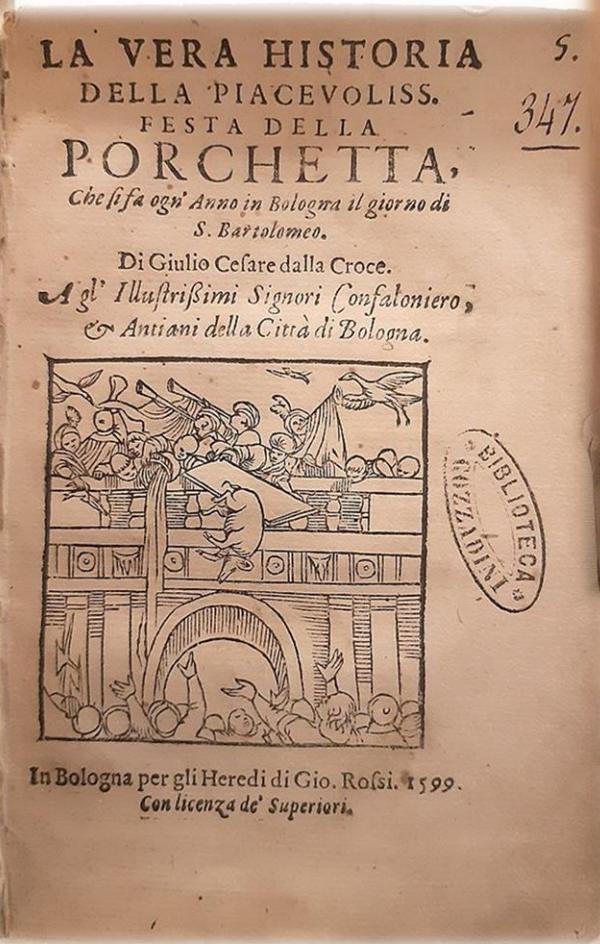
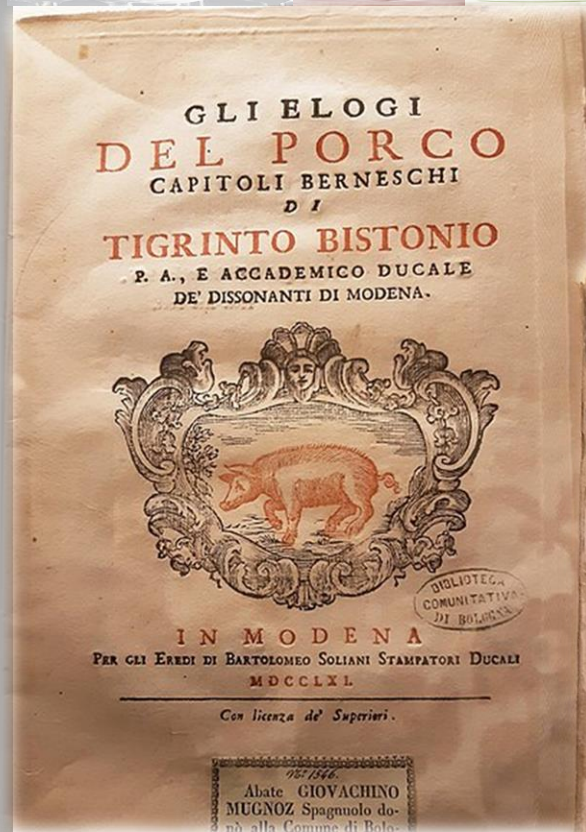
Nel Vangelo

‘Non gettate le cose sante ai cani e le perle ai porci, perché non le mettano sotto i piedi e vi si volgano contro per sbranarvi’

I demoni che scacciati dal corpo umano vengono trasposti in quello di una mandria di porci che precipita nel burrone,

Il figliol prodigo che sconta i suoi peccati di egoismo, superbia e lussuria facendo da guardiano ai porci.

Origini e Storia del Suino



Primo utilizzo del suino a scopo sperimentale



CLAUDE GALIEN

Il medico più famoso dell'antichità, dopo Ippocrate, fu Galeno Claudio di Pegamo (129-200 D.C.). Galeno iniziò con lo studio del corpo umano, ma la Chiesa non permise più le autopsie umane, ritenendole altamente immorali. Non potendo più dissezionare cadaveri umani, Galeno ricorse agli animali, diventando così il padre della vivisezione.

1091-1161 Ibn Zuhr (nome latino di Avenzoar), medico arabo è considerato il padre della chirurgia sperimentale, impiega test sugli animali prima di operare sull'uomo. In tal modo, inventa la tracheotomia. Zuhr eseguiva dissezioni post mortem e autopsie in un periodo in cui erano considerate un vero e proprio tabù. Attraverso i suoi studi autoptici concluse che la scabbia era causata da un parassita, contraddicendo la teoria "umorale".



Nel 1865 Bernard pubblicò il libro "Introduzione allo Studio della Medicina Sperimentale"

Perché il suino domestico?



[Nature](#). 2012; 491(7424): 393–398.

Published online 2012 Nov 14. doi: [10.1038/nature11622](https://doi.org/10.1038/nature11622)

PMCID: PMC3566564

EMSID: [EMS51611](#)

PMID: [23151582](#)

Analyses of pig genomes provide insight into porcine demography and evolution

Lo studio del genoma per

- migliorare la conoscenza dell'animale, così da potenziarne la resistenza alle malattie e il suo impiego come modello per le ricerche biomediche
- confronto con specie evolutivamente più distanti, quali topo, il cane, il cavallo, la mucca ed esseri umani, per scoprire se esistano e la natura dei caratteri in comune.

Scoperte numerose varianti geniche associate, nell'essere umano, a una lunga lista di patologie: obesità, diabete, dislessia, e persino malattie come il Parkinson e l'Alzheimer, a conferma di come il maiale possa rappresentare un modello ideale per lo studio di malattie che colpiscono il genere umano

Perché il suino domestico?

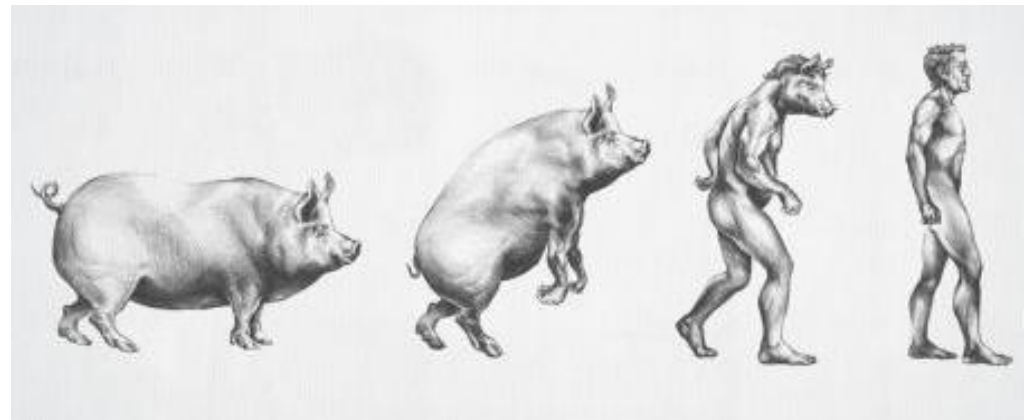
"Se stai esaminando la semplice tossicità, se una malattia ti ucciderà, allora usare un topo va bene. Ma quando si guarda alla terapia farmacologica, non è paragonabile a quella umana. La medicina terapeutica richiede un modello più strettamente correlato", *Lawrence Schook University of Illinois animal geneticists*



Perché il suino domestico ?

Similitudini con l'uomo

- Lo sviluppo dalle fasi giovanili a quelle adulte sono proporzionalmente comparabili. Il suino raggiunge la maturità nello spazio del 4,4% dell'intera vita, l'uomo nel 4,6%.
- Elevata similitudine nella morfologia dei principali organi
- Processi fisiologici molto simili
- Entrambi onnivori



Perché il suino domestico?

VANTAGGI

Allevamento standardizzato e quindi animali molto simili tra loro

Presenza di informazioni circa i protocolli terapeutici e di gestione intra e post procedure

Resistenza alle procedure

Facile stabulazione



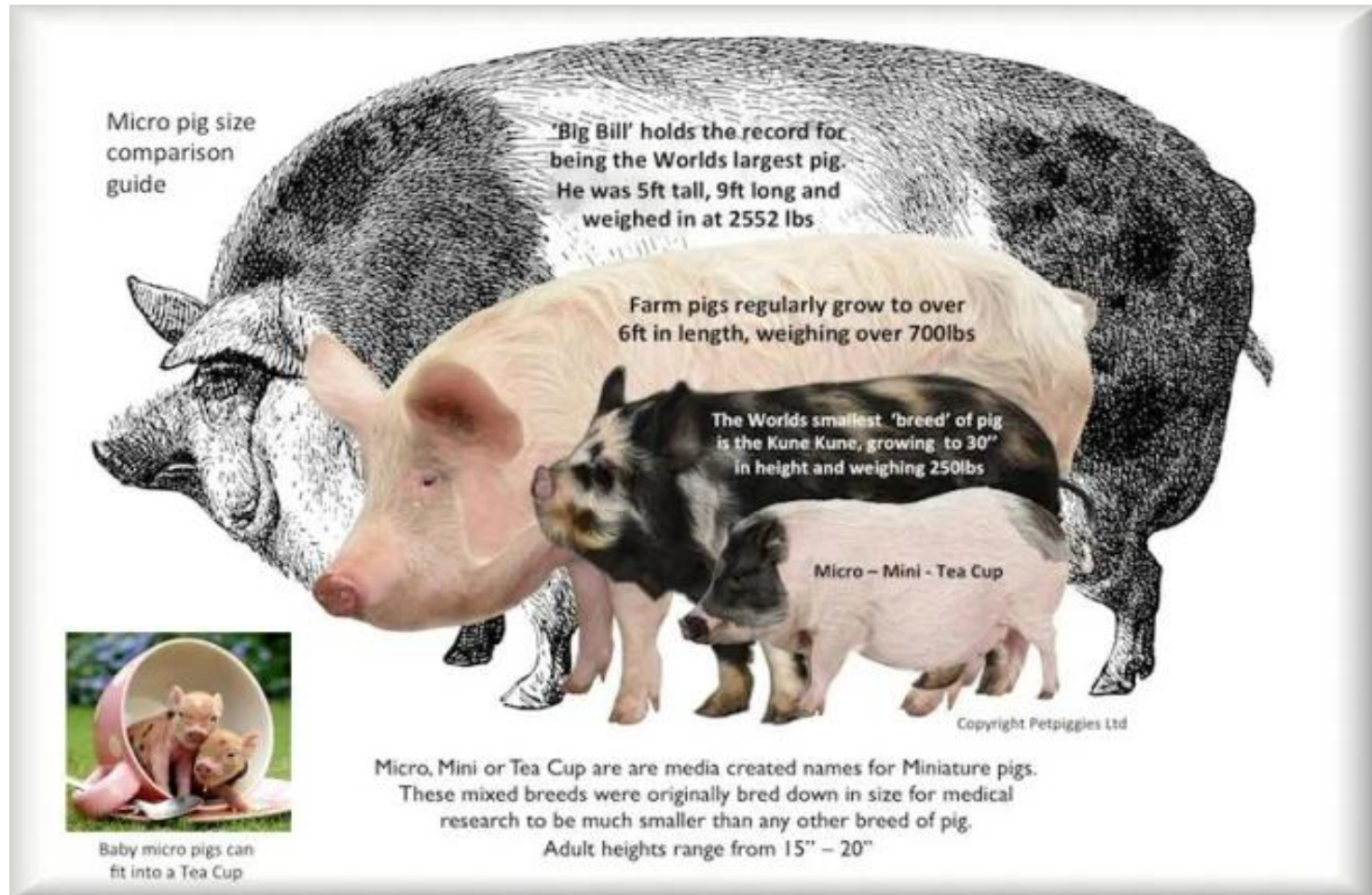
SVANTAGGI

Dimensione da adulti

Castrazione nei maschi

Sostituzione dei Primati non umani e dei Cani

Perché il Minipig



1 ft = 30,48 cm

1 lbs = 2,2 kg

Perché il Minipig

- a) **minipig di Göttingen (1960)**
- b) minipig Hanford (1958),
- c) minipig e il micropig dello Yucatan,
- d) minipig Troll
- e) minipig Sinclair.

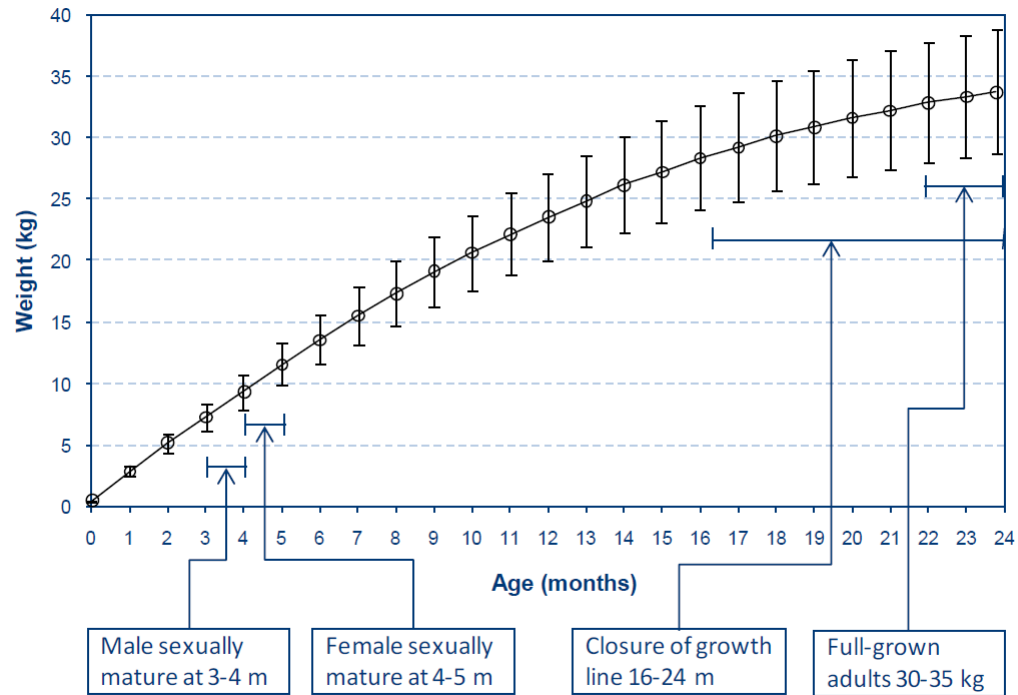


Il minipig di Göttingen è il risultato dell'incrocio tra i maiali vietnamiti, i maiali nani Hormel o Minnesota e la Landrace migliorata dai tedeschi.

A causa della bassa statura, del comportamento relativamente calmo e dell'idoneità per la maggior parte degli scopi di test è diventato il ceppo più utilizzato



Perché il Minipig



L'incremento ponderale durante i primi 12 mesi di vita dovrebbe essere di circa 500 gr alla settimana

Oltre i 12 mesi l'incremento dovrebbe essere di 250 gr/settimana con un peso ideale a 2 anni di 35 Kg

<https://minipigs.dk/goettingen-minipigs/background-data>

Perché il Minipig

- ✓ I minipig di Göttingen raggiungono la maturità sessuale in un'età notevolmente più precoce rispetto alle specie standard non roditori utilizzate negli studi sulla sicurezza dei farmaci, con i verri che raggiungono la maturità a 3-4 mesi e le scrofe a 4-5.
- ✓ Non necessaria la castrazione quindi animali integri
- ✓ Animali docili e puliti; possibilità di svolgere procedure senza sedazione
- ✓ Peso da adulti compatibile con le procedure di imaging e chirurgiche
- ✗ Orecchie piccole, cute molto coriacea

Perché il Minipig

Presenza di dati in letteratura



Possibilità di creare ceppi geneticamente modificati in tempi relativamente più brevi rispetto ad altre specie (primati non umani).

Perché il Minipig



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[Regen Med.](#) Author manuscript; available in PMC 2010 Jul 16.

PMCID: PMC2905042

Published in final edited form as:

NIHMSID: NIHMS211047

[Regen Med.](#) 2006 Jul; 1(4): 405–413.

PMID: [17465832](#)

doi: [10.2217/17460751.1.4.405](#)

LARGE ANIMAL MODELS ARE CRITICAL FOR RATIONALLY ADVANCING REGENERATIVE THERAPIES

[Dustin R Wakeman](#),^{1,2} [Andrew M Crain](#),^{1,2} and [Evan Y Snyder](#)^{2,*}

Monkeys and the minipig may prove to be excellent preclinical models owing to their similar comparative anatomy, pharmacokinetics and physiological and metabolic interactions. These models have proven to be extremely useful for studying endocrinological diseases, such as Type 1 diabetes, and neurological disorders, including Parkinson's disease (PD), spinal cord injury (SCI) and multiple sclerosis (MS). Prudence would argue that clinical trials for diseases in which differences between rodent and human transcend size and scale should require clear and definitive proof-of-concept in at least one relevant large-animal model in order to safeguard patients. This need, of course, is counterbalanced by considerations of the substantial cost, time and ethical circumspection that typically accompanies such research.

Perché il Minipig

Advantages to the use of minipigs include their ready availability and their small size compared with conventional pigs. Extensive data on anatomy, reproductive physiology, clinical parameters and histopathology are available for the Göttingen minipig. Minipigs are also easier to house, handle, dose and sample than non-human primates and there are no zoonoses (in contrast to non-human primates). There are fewer ethical or conservation concerns, sexually mature animals are readily available and global transportation of minipigs is easier.

Minipigs: Elizabeth F McInnes, in Background Lesions in Laboratory Animals, 2012

Ambiti di Utilizzo

...They provide significant advantages over dogs due to their greater tolerance of non steroidal anti-inflammatory drugs, antihypertensive agents and sympathicomimetic drugs (Dincer 2007). In addition, minipigs are advantageous models for human drugs since their digestion is similar to that of humans, and their smaller size makes them more manageable laboratory animals. The minipig offers many advantages as a model in dermal toxicity because of the similarity between porcine and human skin (Mortensen et al 1998, Lavker et al 1991), including similarities in skin thickness, permeability, pigmentation, allergic reaction and reaction to burning. In addition, the gastrointestinal system, digestion and metabolism, as well as the renal and immune systems of minipigs are similar to those in man...similarities to humans in reproductive tract histology, physiology, and in cervical and vaginal secretions and vaginal pH (minipigs are used for intravaginal studies) (Jørgensen et al 1998). Finally, cardiovascular physiology and anatomy, ventricular performance, electrophysiology and coronary artery distribution are similar to those in humans.

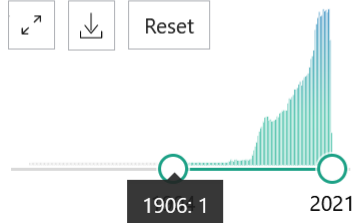
Minipigs: Elizabeth F McInnes, in Background Lesions in Laboratory Animals, 2012

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RESULTS BY YEAR



Swine as models in biomedical research and toxicology testing.

1 Swindle MM, Makin A, Herron AJ, Clubb FJ Jr, Frazier KS.

Cite Vet Pathol. 2012 Mar;49(2):344-56. doi: 10.1177/0300985811402846. Epub 2011 Mar 25.

PMID: 21441112 [Review](#).

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Swine are considered to be one of the major animal species used in translational research, surgical models, and procedural training and are increasingly being used as an alternative to the dog or monkey as the choice of nonrodent species in preclinical toxicologic testing ...

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minipig



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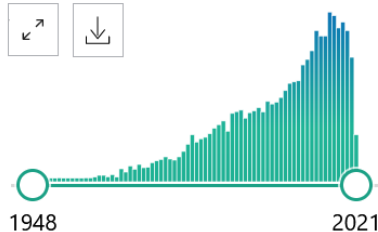
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RESULTS BY YEAR



[Spontaneous and Drug-induced Arteritis/Polyarteritis in the Gottingen Minipig-Review.](#)

1

Cite Dincer Z, Piccicuto V, Walker UJ, Mahl A, McKeag S.

Toxicol Pathol. 2018 Feb;46(2):121-130. doi: 10.1177/0192623318754791.

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PMID: 29471777 [Review.](#)

In the **minipig**, this finding differs in frequency and nature from age-related polyarteritis nodosa in rats or monkeys, and Beagle pain syndrome in dogs. ...The etiology is unknown although it has been considered in **minipigs** as well as in rats, dogs, and monkeys to b ...

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gottingen minipig



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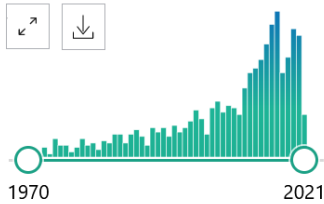
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802 results

RESULTS BY YEAR



TEXT AVAILABILITY

- Abstract
- Free full text



Histomorphometric evaluation of the Gottingen minipig eye.

1 Shrader SM, Mowry RN.

Cite Vet Ophthalmol. 2019 Nov;22(6):872-878. doi: 10.1111/vop.12665. Epub 2019 Mar 21.

PMID: 30895700

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We, therefore, investigated the characteristics of the cornea, retina, and sclera in order to establish baseline histomorphometric data in male and female **Gottingen minipigs**. PROCEDURES: This study utilized paraffin-embedded, Davidson's-fixed, control **Gottingen** ...



Spontaneous and Drug-induced Arteritis/Polyarteritis in the Gottingen Minipig-Review.

2 Dincer Z, Piccicuto V, Walker UJ, Mahl A, McKeag S.

Cite

Toxicol Pathol. 2018 Feb;46(2):121-130. doi: 10.1177/0192623318754791.

PMID: 29471777 [Review](#).

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Vibrio cholerae Enterotoxin in Miniature Pigs

ROBERT J. HECKLY, H. WOLOCHOW, AND C. CHRISTIANSEN

Naval Biological Laboratory, School of Public Health, University of California, Berkeley, California 94720

Received for publication 24 July 1969

Miniature pigs appear to be less sensitive than rabbits to cholera toxin introduced into segments of the ileum.

Cell and Tissue Research (2020) 380:287–304
<https://doi.org/10.1007/s00441-020-03206-9>

REVIEW



The pig as a model for immunology research

Reinhard Pabst¹

Received: 5 March 2020 / Accepted: 12 March 2020 / Published online: 30 April 2020
© Springer-Verlag GmbH Germany, part of Springer Nature 2020

Abstract

The pig is an omnivorous, monogastric species with many advantages to serve as an animal model for human diseases. There are very high similarities to humans in anatomy and functions of the immune system, e.g., the presence of tonsils, which are absent in rodents. The porcine immune system resembles man for more than 80% of analyzed parameters in contrast to the mouse with only about 10%. The pig can easily be bred, and there are less emotional problems to use them as experimental animals than dogs or monkeys. Indwelling cannulas in a vein or lymphatic vessel enable repetitive stress-free sampling. Meanwhile, there are many markers available to characterize immune cells. Lymphoid organs, their function, and their role in lymphocyte kinetics (proliferation and migration) are reviewed. For long-term experiments, minipigs (e.g., Göttingen minipig) are available. Pigs can be kept under gnotobiotic (germfree) conditions for some time after birth to study the effects of microbiota. The effects of probiotics can be tested on the gut immune system. The lung has been used for extracorporeal preservation and immune engineering. After genetic modifications are established, the pig is the best animal model for future xenotransplantation to reduce the problem of organ shortage for organ transplantation. Autotransplantation of particles of lymphnodes regenerates in the subcutaneous tissue. This is a model to treat secondary lymphedema patients. There are pigs with cystic fibrosis and severe combined immune deficiency available.

Keywords Pig · Animal model · Lymphoid organs · Lymph nodes regeneration · Xenotransplantation

Ambiti di Utilizzo: Trapianti di Organo

> *J Surg Res.* 2020 Oct;254:175-182. doi: 10.1016/j.jss.2020.04.026. Epub 2020 May 22.

Heterotopic Transplantation of Allogeneic Vertical Rectus Abdominis Myocutaneous Flaps in Miniature Swine

Matthias Waldner¹, Tarek Y Elgendy², Deokyeol Y Kim³, Sinan Öksüz⁴, Riccardo Schweizer¹,
Wensheng Zhang³, Marta I Minervini⁵, Chiaki Komatsu³, Jan A Plock⁶,
Kia M Washington⁸, Angus W Thomson⁹, Mario G Solari¹⁰

Original Article

Hepatocyte Transplantation to the Liver via the Splenic Artery in a Juvenile Large Animal Model

J. Siefert¹, K. H. Hillebrandt¹, S. Moosburner¹, P. Podrabsky², D. Geisel²,
T. Denecke², J. K. Unger³, B. Sawitzki⁴, S. Gül-Klein¹, S. Lippert¹, P. Tang¹,
A. Reutzel-Selke¹, M. H. Morgul⁵, A. W. Reske⁶, S. Kafert-Kasting⁷,
W. Rüdinger⁷, J. Oetvoes³, J. Pratschke¹, I. M. Sauer¹, and N. Raschzok^{1,8}

Cell Transplantation
2019, Vol. 28(1S) 145-245
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DOI: 10.1177/0963689719885091
journals.sagepub.com/home/ccl
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Review > *Xenotransplantation.* 2019 Jan;26(1):e12492. doi: 10.1111

Progress in multiple genetically modified minipigs for xenotransplantation in China

Dengke Pan¹, Ting Liu², Tiantian Lei², Huibin Zhu³, Yi Wang⁴, Shaoping Deng¹

Affiliations + expand

PMID: 30775816 DOI: 10.1111/xen.12492

Abstract

Pig-to-human organ transplantation provides an alternative for critical shortage of human organs worldwide. Genetically modified pigs are promising donors for xenotransplantation as they show many anatomical and physiological similarities to humans. However, immunological rejection

Ambiti di Utilizzo: Tossicologia



Biomarkers in Toxicology (Second Edition)

2019, Pages 75-89



Chapter 3 - Göttingen Minipigs as Large Animal Model in Toxicology

Henrik Duelund Pedersen, Lars Friis Mikkelsen

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<https://doi.org/10.1016/B978-0-12-814655-2.00003-7>

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Journal of Pharmacological and Toxicological Methods

Volume 74, July–August 2015, Pages 80-92



Review

Comparison of minipig, dog, monkey and human drug metabolism and disposition



Journal of Pharmacological and Toxicological Methods

Volume 62, Issue 3, November–December 2010, Pages 196-220



Original article

The utility of the minipig as an animal model in regulatory toxicology ☆

Gerd Bode ^a , Peter Clausing ^b , Frederic Gervais ^c , Jeanet Loegsted ^d , Jörg Luft ^e , Vicente Nogues ^f , Jennifer Sims ^g , under the auspices of the Steering Group of the *RETHINK* Project

It would be of particular value to gain a better vision of the potential utility of the minipig as a model for the safety testing of new biologics, where the minipig **could potentially replace the use of non-human primates in the testing of some new products.**

Ambiti di Utilizzo: Metabolismo

> [Toxicol Pathol.](#) 2016 Apr;44(3):442-9. doi: 10.1177/0192623315622304. Epub 2016 Feb 16.

A Translational Model for Diet-related Atherosclerosis: Effect of Statins on Hypercholesterolemia and Atherosclerosis in a Minipig

Chidozie Amuzie ¹, John R Swart ², Christopher S Rogers ², Thomas Vihtelic ³, Steven Denham ³, Dale E Mais ³

> [Mol Metab.](#) 2018 Oct;16:180-190. doi: 10.1016/j.molmet.2018.06.015. Epub 2018 Jun 28.

Metabolic syndrome and extensive adipose tissue inflammation in morbidly obese Göttingen minipigs

Simone Renner ¹, Andreas Blutke ², Britta Dobenecker ³, Georg Dhom ⁴, Timo D Müller ⁵, Brian Finan ⁵, Christoffer Clemmensen ⁵, Maren Bernau ⁶, Istvan Novak ⁴, Birgit Rathkolb ⁷, Steffanie Senf ⁸, Susanne Zöls ⁸, Mirjam Roth ⁹, Anna Götz ¹⁰, Susanna M Hofmann ¹¹, Martin Hrabě de Angelis ¹², Rüdiger Wanke ², Ellen Kienzle ³, Armin M Scholz ⁶, Richard DiMarchi ¹³, Mathias Ritzmann ⁸, Matthias H Tschöp ⁵, Eckhard Wolf ¹⁴

Ambiti di Utilizzo: Diabete

> *Am J Physiol Regul Integr Comp Physiol.* 2018 Feb 1;314(2):R252-R264.

doi: 10.1152/ajpregu.00213.2017. Epub 2017 Dec 4.

Microvascular insulin resistance in skeletal muscle and brain occurs early in the development of juvenile obesity in pigs

T Dylan Olver¹, Zachary I Grunewald², Thomas J Jurrissen², Rebecca E K I Paul J LeBlanc³, Teagan R Schnurbusch⁴, Alana M Czajkowski⁴, M Harold R Scott Rector^{2 6 7}, Shawn B Bender^{1 5 6}, Eric M Walters⁴, Craig A Emt



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Author manuscript

Nat Biomed Eng. Author manuscript; available in PMC 2020 May 18.

Published in final edited form as:

Nat Biomed Eng. 2020 May ; 4(5): 499–506. doi:10.1038/s41551-019-0508-y.

Glucose-responsive insulin patch for the regulation of blood glucose in mice and minipigs

Jicheng Yu^{1,2}, Jinqiang Wang^{1,3,4}, Yuqi Zhang^{1,2}, Guojun Chen^{1,3,4}, Weiwei Mao², Yanqi Ye^{1,2}, Anna R. Kahkoska⁵, John B. Buse⁵, Robert Langer^{6,7,8,9,10}, Zhen Gu^{1,3,4,11,12,*}

¹Joint Department of Biomedical Engineering, University of North Carolina at Chapel Hill and North Carolina State University, Raleigh, NC, USA.

Animal Cells and Systems

Anim Cells Syst (Seoul). 2019 Feb; 23(1): 42–49.

Published online 2018 Dec 18. doi: [10.1080/19768354.2018.1554544](https://doi.org/10.1080/19768354.2018.1554544)

PMCID: PMC6394289

PMID: [30834158](https://pubmed.ncbi.nlm.nih.gov/30834158/)

Potential use of transgenic domestic pigs expressing recombinant human erythropoietin in diabetes translation research

Sun-Young Baek,^a Hak-Jae Chung,^a Kyung-Woon Kim,^a Kyu-Ho Cho,^a Inchul Choi,^{b,CONTACT} and Hoon-Taek Lee^c

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Ambiti di Utilizzo: Cardiovascolare



[Am J Physiol Heart Circ Physiol](#). 2019 Oct 1; 317(4): H820–H829.

PMCID: PMC6843016

Published online 2019 Aug 23. doi: [10.1152/ajpheart.00144.2019](#)

PMID: [31441690](#)

Many Avenues to Cardiac Cell Death

Cortical bone-derived stem cell therapy reduces apoptosis after myocardial infarction

[Alexander R. H. Hobby](#),¹ [Thomas E. Sharp](#),^{3rd,2} [Re Sadia Mohsin](#),³ and [Steven R. Houser](#)¹



HEART FAILURE REVIEWS

► [springer.com](#)

[Heart Fail Rev](#). 2019; 24(3): 387–397.

PMCID: PMC6476831

Published online 2019 Jan 5. doi: [10.1007/s10741-018-9762-4](#)

PMID: [30612214](#)

Current animal models for the study of congestion in heart failure: an overview

[Jirka Cops](#),^{1,2,3} [Sibren Haesen](#),¹ [Bart De Moor](#),^{1,4} [Wilfried Mullens](#),^{1,5} and [Dominique Hansen](#)^{1,6,7}

► [Front Biosci \(Landmark Ed\)](#). 2019 Mar 1;24:723-734.

Structural, functional and histological features of a novel ischemic heart failure model

[Yongchun Cui](#)¹, [Fuliang Luo](#)¹, [Bin Li](#)¹, [LiuJun Jia](#)¹, [Peng Peng](#)¹, [Chengliang Luo](#)², [Xin Wang](#)³, [Yue Tang](#)⁴

Ambiti di Utilizzo: Urologia

> [World J Urol.](#) 2017 Jul;35(7):1125-1132. doi: 10.1007/s00345-016-1959-3. Epub 2016 Oct 25.

Collagen cell carriers seeded with human urothelial cells for urethral reconstructive surgery: first results in a xenograft minipig model

Stefan Aufderklamm ¹, Martin Vaegler ², Alexandra Kelp ¹, Sabine Maurer ¹, Leon Gustafsson ¹, Jens Mundhenk ³, Silke Busch ⁴, Lisa Daum ⁵, Arnulf Stenzl ¹, Bastian Amend ⁶, Karl-Dietrich Sievert ¹

> [Eur Surg Res.](#) 2020;61(2-3):95-100. doi: 10.1159/000511399. Epub 2020 Nov 6.

Comparing Aachen Minipigs and Pietrain Piglets as Models of Experimental Pediatric Urology to Human Reference Data

Christina Oetzmann von Sochaczewski ¹, Nikolaus Deigendesch ², Andreas Lindner ³, Jan Baumgart ⁴, Arne Schröder ⁵, Axel Heimann ⁶, Oliver J Muensterer ³

Ambiti di Utilizzo: Neurologia

> [Sci Rep.](#) 2020 Mar 19;10(1):5046. doi: 10.1038/s41598-020-61251-4.

Longitudinal phenotype development in a minipig model of neurofibromatosis type 1

Johanna Uthoff ^{1 2 3}, Jared Larson ¹, Takashi S Sato ¹, Emily Hammond ^{1 2 3}, Kimberly E Schroeder ², Frank Rohret ⁴, Christopher S Rogers ⁴, Dawn E Quelle ^{3 5}, Benjamin W Darbro ^{3 6}, Rajesh Khanna ⁷, Jill M Weimer ⁸, David K Meyerholz ⁹, Jessica C Sieren ^{10 11 12}

> [J Pediatr Surg.](#) 2020 Dec;55(12):2791-2796. doi: 10.1016/j.jpedsurg.2020.03.006. Epub 2020 Mar 25.

Human skin-derived precursor cells xenografted in aganglionic bowel

Anne-Laure Thomas ¹, Jordan S Taylor ¹, James C Y Dunn ²

Affiliations + expand

PMID: 32253016 DOI: [10.1016/j.jpedsurg.2020.03.006](#)

Abstract

Purpose: One in 5000 newborns is diagnosed with Hirschsprung disease each year in the United States. The potential of employing neural crest stem cells to restore the enteric nervous system has been investigated. Skin-derived precursor cells (SKPs) are multipotent progenitor cells that can

Ambiti di Utilizzo: Ortopedia

> [J Orthop Res.](#) 2020 Dec;38(12):2696-2708. doi: 10.1002/jor.24694. Epub 2020 Apr 23.

Transection of the medial meniscus anterior horn results in cartilage degeneration and meniscus remodeling in a large animal model

Sonia Bansal ^{1 2 3}, Liane M Miller ^{1 2}, Jay M Patel ^{1 2}, Kyle D Meadows ⁴, Michael R Eby ^{1 2}, Kamiel S Saleh ^{1 2}, Anthony R Martin ^{1 2}, Brendan D Stoeckl ^{1 2 3}, Michael W Hast ^{1 2 5}, Dawn M Elliott ⁴, Miltiadis H Zgonis ^{1 2}, Robert L Mauck ^{1 2 3}

> [Bone Res.](#) 2019 Oct 24;7:32. doi: 10.1038/s41413-019-0069-4. eCollection 2019.

Human iPSC-derived iMSCs improve bone regeneration in mini-pigs

Pascal Jungbluth ^{# 1}, Lucas-Sebastian Spitzhorn ^{# 2}, Jan Grassmann ¹, Stephan Tanner ¹, David Latz ¹, Md Shaifur Rahman ², Martina Bohndorf ², Wasco Wruck ², Martin Sager ³, Vera Grotheer ¹, Patric Kröpil ⁴, Mohssen Hakimi ⁵, Joachim Windolf ¹, Johannes Schnependahl ¹, James Adjaye ²

> [Ann Anat.](#) 2020 Jan;227:151411. doi: 10.1016/j.aanat.2019.07.012. Epub 2019 Aug 5.

Anatomical feature of knee joint in Aachen minipig as a novel miniature pig line for experimental research in orthopaedics

T Gundula Schulze-Tanzil ¹, Sandeep Silawal ², Mariann Hoyer ³

Review > [Toxicol Pathol.](#) 2018 Jun;46(4):403-407. doi: 10.1177/0192623318770379.

Epub 2018 Apr 22.

Göttingen Minipigs in Ocular Research

[Stephanie M Shrader](#)¹, [William F Greentree](#)¹

Affiliations + expand

PMID: 29683084 DOI: [10.1177/0192623318770379](#)

Since their development in the 1960s, Göttingen minipigs have become a popular nonrodent animal model in biomedical research, especially for ocular studies, because of their ease of handling, size, well-monitored genetics, and ocular anatomy that is similar to humans. The purpose of this mini-review is to introduce the reader to the various ways in which this animal model is currently being utilized in ocular research and to provide an overview of the diagnostic modalities that aid in this research.

> [Curr Eye Res.](#) 2016;41(1):79-87. doi: 10.3109/02713683.2014.997887. Epub 2014 Dec 30.

In Vivo Retinal Vein Bypass Surgery in a Porcine Model

[Li-Jun Shen](#)^{1 2}, [Yi-Qi Chen](#)², [Dan Cheng](#)², [Chaote Zhang](#)², [Lu Jiang](#)², [Mingsheng Hong](#)², [Qian-Yan Kang](#)¹

Ambiti di Utilizzo: Otorinolaringoiatria

> [Anat Rec \(Hoboken\)](#). 2019 Jun;302(6):1024-1038. doi: 10.1002/ar.24098. Epub 2019 Mar 15.

Establishment of a Large Animal Model for Eustachian Tube Functional Study in Miniature Pigs

Feng-Wei An^{1 2}, Hu Yuan^{1 2}, Weiwei Guo^{1 2}, Zhao-Hui Hou^{1 2}, Jian-Ming Cai³, Chun-Cai Luo³, Ning Yu^{1 2}, Qing-Qing Jiang^{1 2}, Wei Cheng^{1 2}, Wei Liu^{4 5}, Shi-Ming Yang²

Affiliations + expand

PMID: 30779320 DOI: [10.1002/ar.24098](#)

[Free article](#)

Abstract

This study was performed to investigate whether miniature pigs are a suitable animal model for studies of the Eustachian tube (ET). Sixteen Chinese experimental miniature pigs were used in this investigation. Ten animals were used for anatomical and morphometric analyses to obtain qualitative and quantitative information regarding the ET. Three animals were used for histological analysis to

Ambiti di Utilizzo: Oncologia

> [Cell Prolif.](#) 2020 Oct;53(10):e12863. doi: 10.1111/cpr.12863. Epub 2020 Sep 1.

IL2RG-deficient minipigs generated via CRISPR/Cas9 technology support the growth of human melanoma-derived tumours

Jilong Ren^{1 2 3}, Dawei Yu^{1 2}, Rui Fu^{1 2}, Peipei An⁴, Renren Sun⁴, Zhengzhu Wang⁴,
Runfa Guo^{1 2}, Haoyun Li^{1 2}, Ying Zhang^{1 2}, Ziyi Li⁴, Yong-Guang Yang⁴, Wei Li^{1 2 3},
Tang Hai^{1 2}, Zheng Hu⁴



[Genes \(Basel\)](#). 2019 Nov; 10(11): 915.

PMCID: PMC6895830

Published online 2019 Nov 9. doi: [10.3390/genes10110915](#)

PMID: [31717496](#)

Melanoma-Bearing Libechov Minipig (MeLiM): The Unique Swine Model of Hereditary Metastatic Melanoma

[Vratislav Horak](#), [Anna Palanova](#), [Jana Cizkova](#), [Veronika Miltrova](#), [Petr Vodicka](#), and [Helena Kupcova Skalnikova](#)*

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Ambiti di Utilizzo: Terapia Rigenerativa



[Sci Transl Med](#). Author manuscript; available in PMC 2016 Jul 14.

Published in final edited form as:

[Sci Transl Med](#). 2016 Jun 15; 8(343): 343ra83.

doi: [10.1126/scitranslmed.aad5904](https://doi.org/10.1126/scitranslmed.aad5904)

PMCID: PMC494

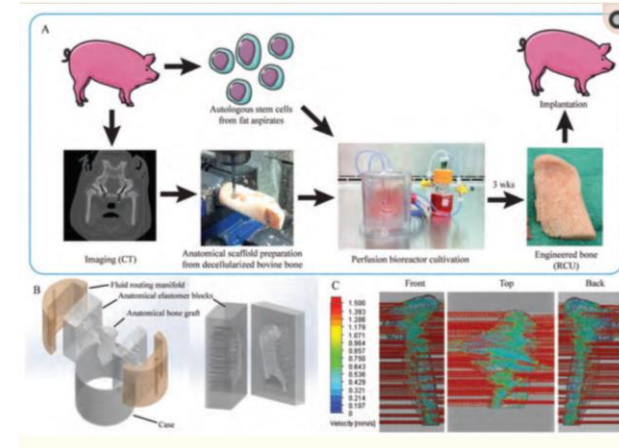
NIHMSID: NIHMS80

PMID: [2730](https://pubmed.ncbi.nlm.nih.gov/2730)

Tissue-Engineered Autologous Grafts for Facial Bone Reconstruction

Sarindr Bhumiratana,¹ Jonathan C. Bernhard,¹ David M. Alfi,² Keith Yeager,¹ Ryan E. Eton,¹ Jonathan Bova,³ Forum Shah,⁴ Jeffrey M. Gimble,^{4,5} Mandi J. Lopez,³ Sidney B. Eisig,¹ and Gordana Vunjak-Novakovic^{1,*}

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[Comparative Study](#) ► [PLoS One](https://doi.org/10.1371/journal.pone.0215875). 2019 Apr 25;14(4):e0215875. doi: 10.1371/journal.pone.0215875.

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Cephalometric studies of the mandible, its masticatory muscles and vasculature of growing Göttingen Minipigs—A comparative anatomical study to refine experimental mandibular surgery

> [Ann Biomed Eng.](#) 2020 Feb;48(2):669-681. doi: 10.1007/s10439-019-02388-w. Epub 2019 Nov 4.

A High-Precision and Miniature Fiber Bragg Grating-Based Force Sensor for Tissue Palpation During Minimally Invasive Surgery

Changhu Lv¹, Shuxin Wang¹, Chaoyang Shi²

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[Int J Nanomedicine.](#) 2018; 13: 3129–3143.

Published online 2018 May 28. doi: [10.2147/IJN.S159480](#)

PMCID: PMC5978460

PMID: [29881270](#)

A polypropylene mesh modified with poly- ϵ -caprolactone nanofibers in hernia repair: large animal experiment

[Barbora East](#),^{1,2} [Martin Plencner](#),^{3,4} [Martin Kralovic](#),^{1,3,5} [Michala Rampichova](#),³ [Vera Sovkova](#),^{1,3,5}
[Karolina Vocetkova](#),^{1,3,5} [Martin Otahal](#),^{6,7} [Zbynek Tonar](#),^{8,9} [Yaroslav Kolinko](#),^{8,9} [Evzen Amler](#),^{1,3,5} and
[Jiri Hoch](#)^{1,10}

Ambiti di Utilizzo: Forense

I List > PLoS One > v.13(6); 2018 > PMC6021042

PLOS ONE



PLoS One. 2018; 13(6): e0198673.

PMCID: PMC6021042

Published online 2018 Jun 27. doi: [10.1371/journal.pone.0198673](https://doi.org/10.1371/journal.pone.0198673)

PMID: [29949606](https://pubmed.ncbi.nlm.nih.gov/29949606/)

Prolactin selectively transported to cerebrospinal fluid from blood under hypoxic/ischemic conditions

[Naoto Tani](#), Data curation, Formal analysis, Investigation, Visualization, Writing – original draft,^{1,2,*} [Tomoya Ikeda](#), Methodology,^{1,2} [Miho Watanabe](#), Investigation,^{3,4,†} [Junko Toyomura](#), Investigation,^{3,†} [Akihiro Ohyama](#), Investigation,^{3,†} and [Takaki Ishikawa](#), Conceptualization, Methodology, Project administration, Writing – review & editing^{1,2}

> [J Forensic Leg Med.](#) 2016 Jul;41:42-8. doi: [10.1016/j.jflm.2016.04.009](https://doi.org/10.1016/j.jflm.2016.04.009). Epub 2016 Apr 9.

A checklist of beetles (Insecta, Coleoptera) on pig carcasses in the suburban area of southwestern China: A preliminary study and its forensic relevance

Zhou Lyu ¹, Li-Hua Wan ², Yong-Qiang Yang ³, Rui Tang ¹, Lyu-Zi Xu ¹

Review > [Dig Dis Sci.](#) 2014 Sep;59(9):2081-90. doi: 10.1007/s10620-014-3308-y.

Epub 2014 Aug 8.

Training methods and models for colonoscopic insertion, endoscopic mucosal resection, and endoscopic submucosal dissection

Naohisa Yoshida ¹, Nilesh Fernandopulle, Yutaka Inada, Yuji Naito, Yoshito Itoh

Ambiti di Utilizzo:

Review > [Toxicol Pathol.](#) 2016 Apr;44(3):299-314. doi: 10.1177/0192623315618292.

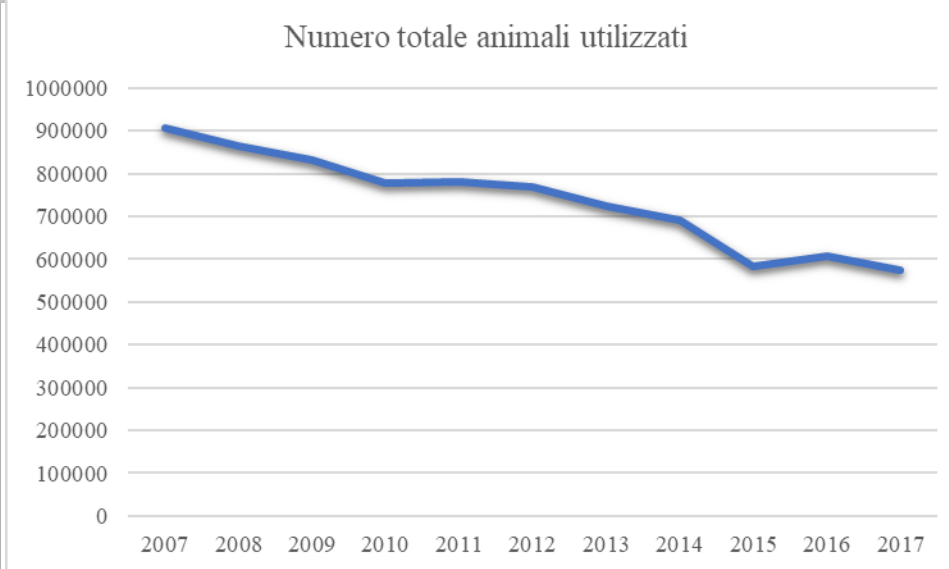
Epub 2016 Feb 2.

Miniature Swine for Preclinical Modeling of Complexities of Human Disease for Translational Scientific Discovery and Accelerated Development of Therapies and Medical Devices

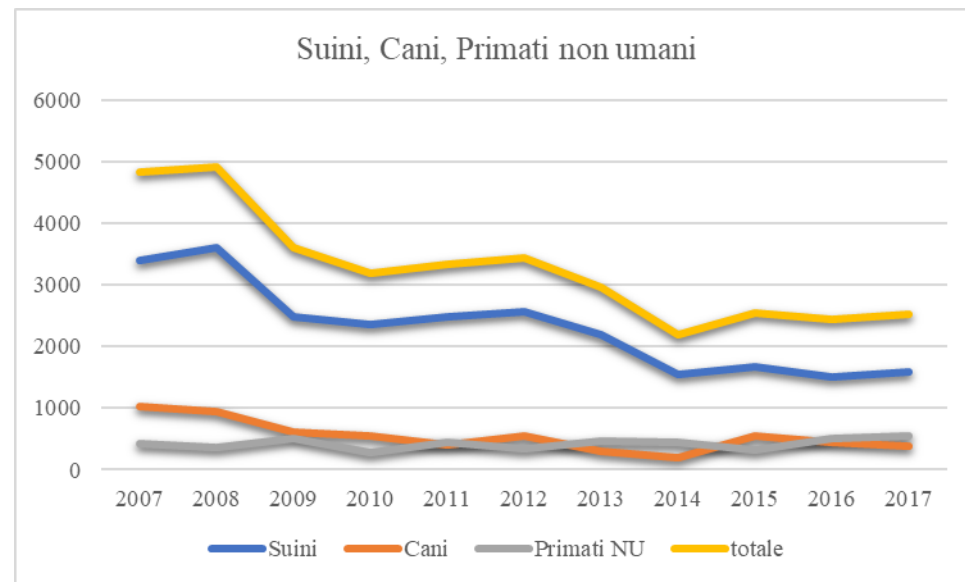
Dominic T Schomberg ¹, Armando Tellez ², Jennifer J Meudt ¹, Dane A Brady ², Krista N Dillon ², Folagbayi K Arowolo ¹, Joan Wicks ², Serge D Rousselle ², Dhanansayan Shanmuganayagam ³

This review highlights the appropriateness of the miniature swine for modeling complex physiologic systems, presenting it as a highly translational preclinical platform to validate efficacy and safety of therapies and devices.

Quanti Suini?



L'andamento dell'utilizzo del suino segue l'andamento totale. L'andamento dei Primati NU e dei cani è legato alla farmacopea nazionale ed internazionale



DUBBI, DOMANDE?



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