Title

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Authors

Bernal-Córdoba, C.
Valldecabres, A.
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et al.

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Clay minerals and related aluminosilicate adsorbents as feed additives in calves: a scoping review protocol

C. Bernal-Córdoba[1,2*], A. Valldecabres[3*], M. Hasan[2], R.B. Branco-Lópes[4], M. Borona-Valencia[3], E.D. Fausak[5], N. Silva del Río[1,2*]

[1]Veterinary Medicine Teaching and Research Center, 18830 Road 112, Tulare, CA
[2]Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis, CA
[3]Facultad de Veterinaria, Universidad Cardenal Herrera-CEU, CEU Universities, Valencia, 46115, Spain
[4]Cooperative Extension, Division of Agriculture and Natural Resources, University of California, Tulare, CA
[5]University Library, University of California, Davis, CA

INTRODUCTION

Rationale

Preweaned calf morbidity in the United States is approximately 35%, with respiratory and gastrointestinal diseases being the most commonly reported conditions (Urie et al., 2018a). Management of these conditions relies heavily on antimicrobial therapy, with nearly 74% of affected calves receiving antibiotics (Shivley et al., 2018; Urie et al., 2018a, 2018b). In the context of the global antimicrobial resistance crisis, interest in natural complementary and alternative strategies to support calf health has increased.

Among these strategies, the use of mineral-based feed additives, including clay minerals and related aluminosilicate adsorbents, has been proposed as a low-cost and practical intervention that can be incorporated into routine calf management (Ariton et al., 2024; Damato et al., 2022). Clays are naturally occurring, fine-grained geological materials that typically consist of mixtures of one or more clay minerals along with associated accessory minerals. Clay minerals themselves are a specific group of silicate minerals built from silicon–oxygen (SiO_4) tetrahedra that form layered structures capable of cleaving into thin sheets, referred to as phyllosilicates. In many phyllosilicates, aluminum partially substitutes for silicon within the silicate framework, resulting in aluminosilicate structures. This substitution contributes to surface charge development and underlies key functional properties of clay minerals, such as adsorption and ion-exchange capacity (Damato et al., 2022; Housecroft, 2020).

In addition to clay minerals, structurally distinct but functionally related aluminosilicate adsorbents, such as zeolites, are also used in animal nutrition. These materials differ from clay minerals in crystal structure, forming three-dimensional networks rather than layered sheets, but share important physicochemical properties, including surface charge, adsorption capacity, and ion-exchange potential (Damato et al., 2022; Housecroft, 2020). Previous work in the veterinary and animal nutrition literature suggests that these aluminosilicate materials may interact with toxins, metabolites, and microorganisms in the gastrointestinal tract through adsorption and surface-mediated mechanisms, although reported effects vary substantially by material type and physicochemical properties (Ariton et al., 2024; Slamova et al., 2011; Williams and Haydel, 2010).

***Corresponding authors:** NSR (nsilvadelrio@ucdavis.edu); AV (ainhoa.valldecabres@uchceu.es); CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

Despite increasing interest in their use, the extent and nature of the evidence supporting clay minerals and related aluminosilicate adsorbents in calves remain unclear. The available literature may be limited in scope or heterogeneous in study design, interventions, and outcomes, potentially constraining the feasibility of quantitative synthesis. In this context, a scoping review is an appropriate approach to systematically map existing studies, characterize interventions and outcomes, identify knowledge gaps, and assess the feasibility of a future systematic review and meta-analysis (Munn et al., 2018; Peters et al., 2020). Accordingly, this protocol outlines the methodology for a scoping review of clay minerals and related aluminosilicate adsorbents used as feed additives in calves.

Objectives

The objective of this protocol is to define and document the methodological approach for a scoping review on clay minerals and related aluminosilicate adsorbents as feed additives in calves, ensuring transparency, reproducibility, and methodological rigor prior to initiation of the review.

The objective of the scoping review is to systematically map the existing evidence on clay minerals and related aluminosilicate adsorbents used as feed additives in calves. Specifically, the review aims to:

- Identify and describe the types of clay minerals and aluminosilicate adsorbents evaluated in calves, including their reported sources, forms, and inclusion strategies.
- Summarize the study designs and methodological characteristics of the available literature, including population characteristics, interventions, comparators, and outcomes.
- Identify knowledge gaps and research trends in the existing evidence and assess the feasibility of future systematic reviews or meta-analyses.

METHODS

This protocol is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (**PRISMA-ScR**; Tricco et al., 2018). This scoping review protocol was developed prior to initiation of the review and registered in the Systematic Reviews for Animals and Food (SYREAF; https://www.syreaf.org/protocol/) database.

Eligibility Criteria

Studies eligibility criteria were defined using the Population–Intervention–Comparator–Outcomes–Study Design (**PICOS**) framework:

- **Population:** Dairy, beef, or veal calves younger than 90 days of life. If age is not reported, calves must have a mean body weight <120 kg at baseline. Calves must be clinically healthy at enrollment.
- **Intervention:** Any form of clay minerals or related aluminosilicate adsorbents administered within the first 90 days of life, with no restrictions on clay/adsorbent type, dose, duration, or route of administration. This includes layered clay minerals (e.g., smectites) as well as structurally distinct aluminosilicate adsorbents (e.g.,

zeolites). Studies evaluating these materials administered either alone or in combination with other compounds (e.g., vitamins, probiotics) will be eligible.

- **Comparator:** Negative control (placebo or non-treated) or a positive control representing standard prophylactic practices (e.g., antibiotics or antibiotic alternatives).
- **Outcomes:** At least one outcome in one or more of the following domains:
    - Immunity: e.g., serum IgG concentration, leukocyte counts.
    - Health: e.g., diarrhea incidence, morbidity, mortality, clinical signs, blood biomarkers.
    - Growth performance: e.g., average daily gain, feed intake, feed efficiency, growth metrics.
- **Study Design:** Primary experimental research, specifically randomized or non-randomized controlled trials.

Exclusion Criteria

Studies will be excluded if they do not meet the inclusion criteria or if any of the following criteria applies:

- Insufficient information to determine population characteristics (i.e., calf age, body weight or health status at enrollment).
- Clay minerals or related aluminosilicate adsorbents administered as a therapeutic treatment for clinically ill calves.
- Non–peer-reviewed publications.
- Articles published before the year 2000.
- Publications not available in English.
- Full-text articles that are not accessible after reasonable efforts to obtain them (including attempts to retrieve the article through institutional library services and by contacting the corresponding authors).

Information Sources

A comprehensive literature search will be conducted with the assistance of an academic veterinary health sciences librarian. The following electronic databases will be searched: CAB Abstracts (via OVID), MEDLINE (PubMed), Scopus (Scopus), and BIOSIS (Web of Science). Reference lists of all eligible full-text articles will be hand-searched using snowballing techniques to identify additional relevant records.

Search Strategy

The preliminary search strategy was developed using a combination of controlled vocabulary (subject headings) and free-text terms derived from relevant literature. Eight calibration papers were used to refine and validate search terms and concepts, which were compared across PubMed and OVID using subject heading analyzers. The final search strategy for each database is provided in Appendix I. Searches will be conducted in accordance with the eligibility criteria defined in this protocol.

Screening

Three independent reviewers will conduct all screening procedures. Reviewers will have veterinary training, and at least one reviewer will have prior experience in scoping and systematic reviews. The screening process will consist of two stages.

Stage 1: Title and Abstract Screening

During Stage 1, each reviewer will independently assess each citation by answering the following four questions using "**Yes**," "**No**," or "**Unclear**":

- **Population:** Does the study include calves (veal, beef, or dairy)?
- **Intervention:** Does the study describe supplementation of clay minerals or related aluminosilicate adsorbents administered to calves in milk, water, or grain?
- **Comparator:** Is the study a controlled trial with a negative control group (placebo or non-treated) or a positive control group (e.g., antibiotics or antibiotic alternatives)?
- **Outcomes:** Does the study evaluate immunity (e.g., serum IgG), health (e.g., clinical signs, blood parameters), or growth performance (e.g., average daily gain)?

A citation will be excluded at Stage 1 if all three reviewers answer "No" to one or more of the four screening questions, indicating that the study does not meet eligibility criteria based on the title and abstract. Citations for which all reviewers answer "Yes" or "Unclear" to all questions will advance to Stage 2.

Discrepancies among reviewers' responses (e.g., one reviewer answers "No" while the others answer "Yes" or "Unclear") will be classified as a conflict, compiled by the lead reviewer, and resolved through discussion during a meeting involving all three reviewers. A final decision to exclude the citation or advance it to Stage 2 will be made only after consensus is reached.

Stage 2: Full-Text Screening

Full-text PDF digital files of all citations retained after Stage 1 will undergo full-text screening by the same three independent reviewers. During Stage 2, reviewers will reassess the same four screening questions used at Stage 1 to verify consistency between the information reported in the title and abstract and the full-text content. This process will allow final eligibility decision of citations in which one or more Stage 1 questions were answered as "Unclear".

Full-text screening will therefore apply the four Stage 1 questions together with the following two additional intervention- and population-related questions:

- **Timing:** Does supplementation begin within the first 90 days of life? If age is not reported, is the mean calf body weight ≤120 kg at enrollment?
- **Purpose of supplementation:** Was supplementation with clay minerals or related aluminosilicate adsorbents initiated when calves were clinically healthy (i.e., not administered as treatment for clinically ill calves)?

Reviewers will answer "Yes" or "No" to all screening questions. The option "Unclear" will not be used at this stage as sufficient information is expected to be available from the full

text. A citation will be excluded at Stage 2 only if all three reviewers answer “No” to one or more of the screening questions. A citation will be included in the scoping review only if all three reviewers answer “Yes” to all full-text screening questions. Conflicts will be resolved as previously described. The primary reason for exclusion will be recorded for each excluded citation for subsequent summarization in the scoping review.

Upon completion of each screening stage, the lead reviewer will compile the screening questions responses, identify discrepancies, and coordinate consensus meetings to resolve conflicts. Inter-reviewer agreement will be calculated separately for each screening stage using simple percent agreement, based on reviewers’ independent decisions prior to consensus meetings. Agreement levels will be reported in the final scoping review manuscript to describe the screening process.

Data Extraction and Management

All retrieved records will be imported into Covidence (Covidence SR; Veritas Health Innovation, Melbourne, Australia), where automated and manual deduplication will be performed. Following deduplication, Covidence will serve as the reference-access platform for reviewers to view and organize citations during the title and abstract screening. Screening decisions will not be recorded in Covidence because the platform supports a maximum of two independent reviewers, whereas this review will involve three reviewers. After the final search strategy is executed and records are deduplicated, the reference dataset in Covidence will remain “locked” for screening to ensure stability and prevent discrepancies arising from database updates. If additional records are identified through updates or supplementary searches, they will be documented separately and processed using the same screening procedures.

Screening and data extraction forms will be created using Microsoft Excel (Microsoft Office 365, Microsoft Corporation, Redmond, WA). Data extraction forms will be pilot tested using three manuscripts to confirm clarity, completeness, and consistent interpretation across reviewers. Reviewers will independently complete data extraction using separate copies of the same Excel spreadsheet. All data extraction files, discrepancy logs, and consensus decisions will be archived in project-specific, version-controlled Excel files to ensure transparency, reproducibility, and traceability of the review process.

Two reviewers will independently extract data from a calibration set consisting of a random 25% sample of citations included in the scoping review. Percent agreement will be calculated as the proportion of extracted data fields with identical entries. If ≥90% agreement is achieved, data extraction will proceed using single extraction with independent verification, whereby one reviewer will extract data from the remaining studies and a second reviewer will verify a random 10% of extracted citations. If agreement during calibration is <90%, both reviewers will independently extract data from all citations and discrepancies will be resolved through discussion or, if necessary, by consultation with a third reviewer.

Data Items and Variables for Extraction

For each eligible study, data will be extracted using a predesigned form and will include the following domains and variables:

- **General Study Characteristics**
  - Author(s) and study title
  - Journal name
  - Country where the study was conducted and year of publication
  - Corresponding author affiliation
  - Funding source(s) and industry involvement (industry funding or industry-affiliated authors)
- **Experimental Design**
  - Sample size (total and per group)
  - Sample size justification (power analysis, estimation, or convenience)
  - Number of experimental arms (i.e., groups)
  - Experimental unit (calf, pen, or farm)
  - Randomization, including:
    - Randomization technique (e.g., computer-generated sequence)
    - Randomization criteria (e.g., age, birth weight, sex)
  - Blinding of caregivers and outcome observers (yes/no + description)
  - Observer training (yes/no) and identity (e.g., researcher, veterinarian)
  - Study duration
- **Population Characteristics**
  - Breed, sex, and age at enrollment
  - Initial body weight
  - Housing system and production system (veal, dairy, beef)
  - Baseline health status at enrollment (e.g., clinical examination)
  - Assessment of passive transfer (e.g., serum IgG, Brix %, total protein)
- **Intervention Characteristics**
  - Type of clay mineral or aluminosilicate adsorbent
  - Single-material or multi-material formulation
  - Source and commercial product name/company and company location
  - Chemical composition
  - Active material concentration in the product and associated units
  - Initial dose and dose adjustments and associated units
  - Start day of supplementation (day of life)
  - Frequency and duration of supplementation (days)
  - Administration route (e.g., milk, grain, bolus, water, drench)
  - Whether the material was mixed with feed (yes/no)
  - Co-interventions or additional compounds administered with the material (yes/no; if yes, specify).
- **Comparator Characteristics**
  - Type (negative control or positive control)
  - Compound/product
  - Dose and administration route
  - Duration of administration
  - Additional notes regarding placebo or control conditions
- **Outcome Data:** Outcome data will be extracted according to two complementary dimensions: outcome domain and nature of the variable. Outcomes will be grouped into three predefined domains (immunity, health, and growth performance). Within

each domain, outcomes will be classified as continuous, dichotomous, or categorical/ordinal, and extracted accordingly.

- **Continuous Outcomes:** unit and method of measurement, time point(s), frequency (if applicable), mean values per group, standard deviation or standard error, sample size per group, 95% confidence intervals, and P-values.
- **Dichotomous Outcomes:** outcome definition, time point or duration of evaluation, number of events per group, total number of animals per group, proportion affected, effect size (odds ratio or relative risk, if reported), 95% confidence intervals, and P-values.
- **Categorical or Ordinal Outcomes:** outcome definition, description of the scale used, time point or duration of evaluation, frequency of measurement (if applicable), number of animals per category and per group, summary measures (e.g., medians, interquartile ranges), statistical methods used, and reported P-values or effect estimates.

Data Charting

The charting process will be descriptive and conducted in accordance with the PRISMA-ScR (Tricco et al., 2018). A PRISMA-ScR flow diagram will be generated to summarize the number of records identified, screened, assessed for eligibility, and included in the review. Findings from eligible studies will be synthesized narratively and summarized using tables and figures to describe study characteristics, interventions, and outcomes. No quantitative synthesis or meta-analysis will be conducted.

Amendments

Any amendments to this protocol will be documented, justified, and reported in the final scoping review manuscript.

Data Availability

All data generated during this scoping review, including study selection records, data extraction forms, extracted datasets, and analytic outputs, will be made available upon reasonable request and, where appropriate, through an open-access repository.

References

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Damato, A., Vianello, F., Novelli, E., Balzan, S., Gianesella, M., Giaretta, E., & Gabai, G. (2022). Comprehensive Review on the Interactions of Clay Minerals With Animal Physiology and Production. *Frontiers in Veterinary Science*, *9*, 889612. https://doi.org/10.3389/fvets.2022.889612

Housecroft, C. E. (2020). Silicates, Aluminosilicates and Biogenic Silica. *Chimia*, *74*(12), 1022–1023. https://doi.org/10.2533/chimia.2020.1022

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D., Heinrichs, A. J., James, R., Maas, J., & Sterner, K. (2020). Consensus recommendations on calf- and herd-level passive immunity in dairy calves in the United States. *Journal of Dairy Science*, *103*(8), 7611–7624. https://doi.org/10.3168/jds.2019-17955

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, *18*(1), 143. https://doi.org/10.1186/s12874-018-0611-x

Peters, M. D. J., Marnie, C., Tricco, A. C., Pollock, D., Munn, Z., Alexander, L., McInerney, P., Godfrey, C. M., & Khalil, H. (2020). Updated methodological guidance for the conduct of scoping reviews. *JBI Evidence Synthesis*, *18*(10), 2119. https://doi.org/10.11124/JBIES-20-00167

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Slamova, R., Trckova, M., Vondruskova, H., Zraly, Z., & Pavlik, I. (2011). Clay minerals in animal nutrition. *Applied Clay Science*, *51*(4), 395–398. https://doi.org/10.1016/j.clay.2011.01.005

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, *169*(7), 467–473. https://doi.org/10.7326/M18-0850

Urie, N. J., Lombard, J. E., Shivley, C. B., Kopral, C. A., Adams, A. E., Earleywine, T. J., Olson, J. D., & Garry, F. B. (2018a). Preweaned heifer management on US dairy operations: Part V. Factors associated with morbidity and mortality in preweaned dairy heifer calves. *Journal of Dairy Science*, *101*(10), 9229–9244. https://doi.org/10.3168/jds.2017-14019

Urie, N. J., Lombard, J. E., Shivley, C. B., Kopral, C. A., Adams, A. E., Earleywine, T. J., Olson, J. D., & Garry, F. B. (2018b). Preweaned heifer management on US dairy operations: Part I. Descriptive characteristics of preweaned heifer raising practices. *Journal of Dairy Science*, *101*(10), 9168–9184. https://doi.org/10.3168/jds.2017-14010

Williams, L. B., & Haydel, S. E. (2010). Evaluation of the medicinal use of clay minerals as antibacterial agents. *International Geology Review*, *52*(7/8), 745–770. https://doi.org/10.1080/00206811003679737

APPENDIX I – Preliminary Search Strategy

PRISMA-S Template (based on v1.0 retrieved from https://osf.io/2ybwn/)

Item 1: Databases and Interfaces Searched:

Database	Interface	Date Coverage	Date Searched
CAB Abstracts (included products: CAB ABSTRACTS, VetMed Resource, CABI Full Text, Global Health, Animal Health and Production Compendium (AHPC))	OVID	1973 to Present	17 October 2025
Medline (included products: Medline, in process citations, "ahead of print" citations, out-of-scope citations, journals indexing prior to Medline inclusion, pre-1966 citations, PubMed Central, author manuscripts NIH funding, NCBI Bookshelf)	PubMed	1966 to Present	17 October 2025
Scopus	Scopus	1996 to Present	17 October 2025
Biosis	Web of Science	1926 to Present	17 October 2025

Simultaneous Searches: Not Applicable.

Item 2: Other Online Resources (As Needed): Not planned at this time.

Manual Searching (searching relevant journals Table of Contents): Not Planned at this time.

Citation Searching and Text Analysis:

Article Citation:
Fratrić, Natalija, et al. "The effect of a clinoptilolite based mineral adsorber on concentrations of immunoglobulin G in the serum of newborn calves fed different amounts of colostrum." Acta Veterinaria-Beograd 55.1 (2005): 11-21.
Fratrić, Natalija, et al. "The effect of mineral adsorbent in calf diet colostrum on the levels of serum immunoglobulin G, protein and glucose." Acta Veterinaria-Beograd 57.2-3 (2007): 169-180.
Marc, Simona, et al. "Serum protein electrophoretic pattern in neonatal calves treated with clinoptilolite." Molecules 23.6 (2018): 1278.

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

Mohri, Mehrdad, Hesam A. Seifi, and F. Daraei. "Effects of short-term supplementation of clinoptilolite in colostrum and milk on hematology, serum proteins, performance, and health in neonatal dairy calves." Food and chemical toxicology 46.6 (2008): 2112-2117.
Mohri, Mehrdad, Hesam A. Seifi, and M. O. H. S. E. N. Maleki. "Effects of short-term supplementation of clinoptilolite in colostrum and milk on the concentration of some serum minerals in neonatal dairy calves." Biological trace element research 123 (2008): 116-123.

Process: Key articles were identified by the authors and keywords were mined by finding references in PubMed and CAB Abstracts. Keywords were collected and compared with keywords already utilized.

Contacts (Researchers contacted for additional information): Not planned at this time.

Additional Methodologies Not Listed Above: Citation tracking ("snowball")

Process: Articles that were included for extraction after title/abstract and full text screening were utilized for forward and backward citation searching in Scopus.

Limits and Restrictions

- Date and Time Period: 2000 to current
- Language: English
- Publication status: Peer reviewed
- Species Included: Calves
- Study Design: Clinical trials
- Database Subset: Not applicable
- Pre-specified cut-off or saturation point for results: Not applicable
- Other Restrictions: Not applicable

Search Filters:

Database	Interface	Search Filters Applied
CAB Abstracts	OVID	Limit to English Language, year limits (2000 to current), and Article Document Type
Medline	PubMed	English Language and year limits (2000 to current)
Scopus	Scopus	English Language, year limits (2000 to current) and Article Document Type
Biosis	Web of Science	English Language, year limits (2000 to current) and Article Document Type

Item 3: Full Search Strategy:

Search Database: CABDirect

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

Search ID	Terms (copy and paste)	Results
#1 calves	(("calves" or "calf diseases").de. OR (calf or calves).ab,ti.)	151,819
#2	("adsorbent*" or "clinoptilolite" or "Zeolite*" or "clinosorb" or "sepiolite" or "Halloysite" or "zeolite" or "clinoptilolite" or "sepiolite" or "smectite" or "diosmectite" or "montmorillonite" or "bentonite" or "kaolin" or "palygorskite" or "attapulgite" or "perlite" or "sepiolite" or "Clay" or "clay minerals" or "aluminum silicate" or "allophane" or "bauxite" or "beidellite" or "bentonite" or "chlorite" or "dickite" or "glauconite" or "halloysite" or "hectorite" or "illite" or "imogolite" or "intergrade minerals" or "interstratified minerals" or "kaolinite" or "montmorillonite" or "nontronite" or "palygorskite" or "sepiolite" or "smectites" or "vermiculite").ab,ti. OR ("clinoptilolite" or "adsorbents" or "clay minerals" or "allophane" or "bauxite" or "beidellite" or "bentonite" or "chlorite" or "dickite" or "glauconite" or "halloysite" or "hectorite" or "illite" or "imogolite" or "intergrade minerals" or "interstratified minerals" or "kaolinite" or "montmorillonite" or "nontronite" or "palygorskite" or "sepiolite" or "smectites" or "vermiculite").de.)	221,879
#3	#1 AND #2	379
#4	Limit to English and articles	136
#5	Limit to 2000 to current	102
Copy and Paste OVID	(("adsorbent*" or "clinoptilolite" or "Zeolite*" or "clinosorb" or "sepiolite" or "Halloysite" or "zeolite" or "clinoptilolite" or "sepiolite" or "smectite" or "diosmectite" or "montmorillonite" or "bentonite" or "kaolin" or "palygorskite" or "attapulgite" or "perlite" or "sepiolite" or "Clay" or "clay minerals" or "aluminum silicate" or "allophane" or "bauxite" or "beidellite" or "bentonite" or "chlorite" or "dickite" or "glauconite" or "halloysite" or "hectorite" or "illite" or "imogolite" or "intergrade minerals" or "interstratified minerals" or "kaolinite" or "montmorillonite" or "nontronite" or "palygorskite" or "sepiolite" or "smectites" or "vermiculite").ab,ti. OR ("clinoptilolite" or "adsorbents" or "clay minerals" or "allophane" or "bauxite" or "beidellite" or "bentonite" or "chlorite" or "dickite" or "glauconite" or "halloysite" or "hectorite" or "illite" or "imogolite" or "intergrade minerals" or "interstratified minerals" or "kaolinite" or "montmorillonite" or "nontronite" or "palygorskite" or "sepiolite" or "smectites" or "vermiculite").de.) AND (("calves" or "calf diseases").de. OR (calf or calves).ab,ti.)	

Search Database: PubMed

Search ID	Terms (copy and paste)	Results
#1 species	“Calf”[tiab] OR “calves”[tiab]	74,598
#2	"Zeolites"[Mesh] OR “zeolite*”[tiab] OR "clinoptilolite" [Supplementary Concept] OR “clinoptilolite”[tiab] OR “Klinosorb”[tiab] OR “adsorbent”[tiab] OR “sepiolite”[tiab] OR "Calcium Aluminosilicate/therapeutic use"[Mesh] OR “adsorbent*”[tiab] or “clinoptilolite”[tiab] or “Zeolite*”[tiab] or “clinosorb”[tiab] or “sepiolite”[tiab] or “Halloysite”[tiab] OR “smectite”[tiab] OR “diosmectite”[tiab] OR “montmorillonite”[tiab] OR “bentonite”[tiab] OR “kaolin”[tiab] OR “palygorskite”[tiab] OR “attapulgite”[tiab] OR “perlite”[tiab] OR “sepiolite”[tiab] OR “Clay”[tiab] OR “clay minerals”[tiab] OR “aluminum	84,886

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

	silicate”[tiab] OR “allophane”[tiab] OR “bauxite”[tiab] OR “beidellite”[tiab] OR “bentonite”[tiab] OR “chlorite”[tiab] OR “dickite”[tiab] OR “glauconite”[tiab] OR “halloysite”[tiab] OR “hectorite”[tiab] OR “illite”[tiab] OR “imogolite”[tiab] OR “intergrade minerals”[tiab] OR “interstratified minerals”[tiab] OR “kaolinite”[tiab] OR “montmorillonite”[tiab] OR “nontronite”[tiab] OR “palygorskite”[tiab] OR “sepiolite”[tiab] OR “smectites”[tiab] OR “vermiculite”[tiab]	
#3	#1 AND #2	104
#4	#3 AND (english[Filter]))	97
#5	#4 AND (2000:2025[pdat])	52
Copy and paste	(("Zeolites"[MeSH Terms] OR "zeolite*"[Title/Abstract] OR "clinoptilolite"[Supplementary Concept] OR "clinoptilolite"[Title/Abstract] OR "adsorbent"[Title/Abstract] OR "sepiolite"[Title/Abstract] OR "calcium aluminosilicate/therapeutic use"[MeSH Terms] OR "adsorbent*"[Title/Abstract] OR "clinoptilolite"[Title/Abstract] OR "zeolite*"[Title/Abstract] OR "sepiolite"[Title/Abstract] OR "Halloysite"[Title/Abstract] OR "smectite"[Title/Abstract] OR "diosmectite"[Title/Abstract] OR "montmorillonite"[Title/Abstract] OR "bentonite"[Title/Abstract] OR "kaolin"[Title/Abstract] OR "palygorskite"[Title/Abstract] OR "attapulgite"[Title/Abstract] OR "perlite"[Title/Abstract] OR "sepiolite"[Title/Abstract] OR "Clay"[Title/Abstract] OR "clay minerals"[Title/Abstract] OR "aluminum silicate"[Title/Abstract] OR "allophane"[Title/Abstract] OR "bauxite"[Title/Abstract] OR "beidellite"[Title/Abstract] OR "bentonite"[Title/Abstract] OR "chlorite"[Title/Abstract] OR "dickite"[Title/Abstract] OR "glauconite"[Title/Abstract] OR "Halloysite"[Title/Abstract] OR "hectorite"[Title/Abstract] OR "illite"[Title/Abstract] OR "imogolite"[Title/Abstract] OR "kaolinite"[Title/Abstract] OR "montmorillonite"[Title/Abstract] OR "nontronite"[Title/Abstract] OR "palygorskite"[Title/Abstract] OR "sepiolite"[Title/Abstract] OR "smectites"[Title/Abstract] OR "vermiculite"[Title/Abstract]) AND ("Calf"[Title/Abstract] OR "calves"[Title/Abstract])) AND ((english[Filter]) AND (2000:2025[pdat]))	

Search Database: Scopus

Search ID	**Terms (copy and paste)**	**Results**
#1 species	TITLE-ABS-KEY ("calf" OR "calves")	120,334
#2 clay minerals	TITLE-ABS-KEY ("adsorbent*" OR "clinoptilolite" OR "Zeolite*" OR "clinosorb" OR "sepiolite" OR "Halloysite" OR "zeolite" OR "clinoptilolite" OR "sepiolite" OR "smectite" OR "diosmectite" OR "montmorillonite" OR "bentonite" OR "kaolin" OR "palygorskite" OR "attapulgite" OR "perlite" OR "sepiolite" OR "Clay" OR "clay minerals" OR "aluminum silicate" OR "allophane" OR "bauxite" OR "beidellite" OR "bentonite" OR "chlorite" OR "dickite" OR "glauconite" OR "halloysite" OR "hectorite" OR "illite" OR "imogolite" OR "intergrade minerals" OR "interstratified	658,224

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

	minerals" OR "kaolinite" OR "montmorillonite" OR "nontronite" OR "palygorskite" OR "sepiolite" OR "smectites" OR "vermiculite")	
#3	#1 AND #2	242
#4	#3 AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (LANGUAGE,"English"))	128
Copy and paste	(TITLE-ABS-KEY ("adsorbent*" OR "clinoptilolite" OR "Zeolite*" OR "clinosorb" OR "sepiolite" OR "Halloysite" OR "zeolite" OR "clinoptilolite" OR "sepiolite" OR "smectite" OR "diosmectite" OR "montmorillonite" OR "bentonite" OR "kaolin" OR "palygorskite" OR "attapulgite" OR "perlite" OR "sepiolite" OR "Clay" OR "clay minerals" OR "aluminum silicate" OR "allophane" OR "bauxite" OR "beidellite" OR "bentonite" OR "chlorite" OR "dickite" OR "glauconite" OR "halloysite" OR "hectorite" OR "illite" OR "imogolite" OR "intergrade minerals" OR "interstratified minerals" OR "kaolinite" OR "montmorillonite" OR "nontronite" OR "palygorskite" OR "sepiolite" OR "smectites" OR "vermiculite")) AND (TITLE-ABS-KEY ("calf" OR "calves")) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (DOCTYPE,"ar"))	

Search Database: Biosis

Search ID	**Terms (copy and paste)**	**Results**
#1 species	TS=(calf or calves)	115,385
#2 clay minerals	TS=("adsorbent*" OR "clinoptilolite" OR "Zeolite*" OR "clinosorb" OR "sepiolite" OR "Halloysite" OR "zeolite" OR "clinoptilolite" OR "sepiolite" OR "smectite" OR "diosmectite" OR "montmorillonite" OR "bentonite" OR "kaolin" OR "palygorskite" OR "attapulgite" OR "perlite" OR "sepiolite" OR "Clay" OR "clay minerals" OR "aluminum silicate" OR "allophane" OR "bauxite" OR "beidellite" OR "bentonite" OR "chlorite" OR "dickite" OR "glauconite" OR "halloysite" OR "hectorite" OR "illite" OR "imogolite" OR "intergrade minerals" OR "interstratified minerals" OR "kaolinite" OR "montmorillonite" OR "nontronite" OR "palygorskite" OR "sepiolite" OR "smectites" OR "vermiculite")	141,430
#3	#1 AND #2	249
#4	#3 AND English AND articles AND AND PY=(2000 OR 2001 OR 2002 OR 2003 OR 2004 OR 2005 OR 2006 OR 2007 OR 2008 OR 2009 OR 2010 OR 2011 OR 2012 OR 2013 OR 2014 OR 2015 OR 2016 OR 2017 OR 2018 OR 2019 OR 2020 OR 2021 OR 2022 OR 2023 OR 2024 OR 2025)	108
Copy and paste (add English and article filter)	(TS=("adsorbent*" OR "clinoptilolite" OR "Zeolite*" OR "clinosorb" OR "sepiolite" OR "Halloysite" OR "zeolite" OR "clinoptilolite" OR "sepiolite" OR "smectite" OR "diosmectite" OR "montmorillonite" OR "bentonite" OR "kaolin" OR "palygorskite" OR "attapulgite" OR "perlite" OR "sepiolite" OR "Clay" OR "clay minerals" OR "aluminum silicate" OR "allophane" OR "bauxite" OR "beidellite" OR "bentonite" OR "chlorite" OR "dickite" OR "glauconite" OR "halloysite" OR "hectorite" OR "illite" OR "imogolite" OR "intergrade minerals" OR "interstratified	

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)

	minerals" OR "kaolinite" OR "montmorillonite" OR "nontronite" OR "palygorskite" OR "sepiolite" OR "smectites" OR "vermiculite") AND TS=(calf or calves)) AND (DT==("ARTICLE") AND LA==("ENGLISH")) AND PY=(2000 OR 2001 OR 2002 OR 2003 OR 2004 OR 2005 OR 2006 OR 2007 OR 2008 OR 2009 OR 2010 OR 2011 OR 2012 OR 2013 OR 2014 OR 2015 OR 2016 OR 2017 OR 2018 OR 2019 OR 2020 OR 2021 OR 2022 OR 2023 OR 2024 OR 2025)	

Updates: No updates at this time

Search Designers:

Information Specialists or Librarians involved in process were: EDF

Additional input from content experts in project: CB-C, AV, & NSdR

Corresponding authors: NSR (nsilvadelrio@ucdavis.edu), AV (ainhoa.valldecabres@uchceu.es), CBC (crbernalcordoba@ucdavis.edu; crbernalc@gmail.com)