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HANDOUT

ZOO620

Research Methods in Zoology

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ZOO620

Research Methods in Zoology

Study Handout

Complete lecture-wise notes for Virtual University students

About This Handout

This handout covers ZOO620 Research -- the field manual for zoological investigation, from question to publication. It serves the research capstone: designing, executing, analyzing, and communicating a real study. The exam rewards design critique, test selection, and ethical reasoning. After each lesson, close the handout and design one study element from memory -- research is learned by designing.

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Lesson 1: The Nature of Zoological Research

Learning Objectives

- Define zoological research
- Map research types
- Apply the 3Rs
- Design ethically

What zoological research is: systematic investigation of animal life -- from molecules to ecosystems -- answering questions through evidence. The research cycle: observe -> question -> hypothesize -> design -> collect -> analyze -> interpret -> communicate -> new questions. Why this course matters: ZOO620 is the research capstone -- the thesis/project course; these lessons are the field manual for doing it honestly and well.

Types: descriptive (what exists? -- faunal surveys, taxonomy), experimental (what causes? -- controlled manipulations), comparative (how do species differ? -- phylogeny's power), and applied (fisheries, pest control, conservation). Basic vs applied -- the false war: taxonomy underpins conservation; physiology underpins medicine. Levels: molecular, organismal, population, ecosystem -- pick your level deliberately.

Research ethics: animal welfare (the 3Rs -- Replace, Reduce, Refine; institutional ethics committee approval -- required!), field ethics (permits, protected areas, minimal disturbance), and academic integrity (no fabrication, falsification, plagiarism -- the career-enders). The exam's stance question: 'defend the 3Rs with a study design.'

Key Terms & Definitions

- 3Rs — Replace, Reduce, Refine.
- Research cycle — Observe to communicate.
- Basic vs applied — The false war; both matter.
- Academic integrity — No fabrication/falsification/plagiarism.

Example / Illustration

- Testing a pesticide on fish: Replace (cell lines first), Reduce (power analysis for minimum n), Refine (humane endpoints, anesthesia) -- the ethics committee expects exactly this reasoning.

Lesson Summary

- Research: systematic, cyclical, leveled.
- 3Rs govern animal work.
- Integrity is non-negotiable.

Exam Pointers — Very Important

★ Apply the 3Rs to a proposed vertebrate study -- the ethics staple.

Lesson 2: Questions, Hypotheses, Literature

Learning Objectives

- Formulate FINER questions
- State hypotheses
- Identify variables
- Review literature

From curiosity to question: good questions are specific, answerable, and significant -- 'Do urban crows solve novel foraging puzzles faster than rural crows?' beats 'study crows'. Sources: literature gaps, field observations, conservation needs, supervisor expertise. The FINER criteria (Feasible, Interesting, Novel, Ethical, Relevant) -- run every question through FINER.

Hypotheses: testable predictions -- the null (H0: no difference) and alternative (H1); directional vs non-directional; predictions operationalized ('latency to solve in seconds'). Variables: independent (what you manipulate/classify), dependent (what you measure), controlled/confounding (what you hold constant or randomize). Operational definitions -- 'boldness' means nothing until defined as 'latency to approach novel object'.

Literature review: the foundation -- search (Google Scholar, Zoological Record), read critically (methods first!), synthesize (tables of findings), and cite (Zotero/Mendeley; the journal's style). The review justifies the question: 'no study has tested X in Pakistani fauna' -- the gap statement. The exam: 'evaluate a research question with FINER.'

Key Terms & Definitions

- FINER — Feasible, Interesting, Novel, Ethical, Relevant.
- H0 / H1 — Null / alternative hypotheses.
- Operational definition — Concept made measurable.
- Gap statement — What no study has done.

Example / Illustration

- 'Study fish' -> 'Does agricultural runoff reduce gill ATPase activity in Labeo rohita fingerlings?' H0: no difference; IV: runoff concentration; DV: enzyme activity; controlled: temperature, pH, size.

Lesson Summary

- Specific, answerable, significant.
- H0/H1; operationalize everything.
- The review justifies the question.

Exam Pointers — Very Important

★ Refine a vague topic into a FINER question with hypotheses -- the design staple.

Lesson 3: Experimental and Field Design

Learning Objectives

- Design experiments
- Plan field studies
- Avoid pseudoreplication
- Size samples by power

Experimental design: control vs treatment, randomization (the confounder-killer), replication (n -- the power question), and blinding (observer bias -- the experimenter who 'knows' sees what she expects). Designs: completely randomized, randomized block (blocking a known gradient -- pond depth), paired/matched, before-after-control-impact (BACI -- the field ecologist's friend), and factorial (two factors' interaction).

Field study design: transects, quadrats, mark-recapture (Lincoln-Petersen estimator -- N = (M*C)/R; assumptions: closed population, equal catchability), point counts (birds), camera traps (mammals), and eDNA (water samples' genetic traces -- the revolution!). Sampling: random, stratified, systematic -- and the sins (convenience sampling, pseudoreplication -- Hurlbert's famous critique; the exam's trap!).

Sample size: power analysis (G*Power -- effect size, alpha 0.05, power 0.8); pilot studies (the wise investment); and the ethics-statistics handshake (minimum n that still answers -- the 3Rs again). The exam: 'critique this design' -- hunt pseudoreplication, confounding, and missing controls.

Key Terms & Definitions

- Pseudoreplication — Hurlbert; replicates that aren't.
- BACI — Before-after-control-impact design.
- Lincoln-Petersen — N=(M*C)/R estimator.
- Power analysis — Right-sized n; 0.8 power.

Example / Illustration

- 'Ten fish in one treated tank vs ten in one control tank' -- n=1 per treatment (pseudoreplication!); fix: multiple tanks per treatment, randomized positions, blinded measurement.

Lesson Summary

- Randomize, replicate, blind.
- BACI and mark-recapture: field classics.
- Power your n; pilot first.

Exam Pointers — Very Important

★ Critique a flawed field design -- the methods practical.

Lesson 4: Biostatistics for Zoologists

Learning Objectives

- Classify data
- Choose correct tests
- Report completely
- Use R and open science

Data types: categorical (species, sex), ordinal (abundance ranks), continuous (weight, length) -- the type dictates the test. Descriptive: mean/median/mode, SD/SE, confidence intervals; visualize first (boxplots beat tables for spotting trouble). Normality: check (Shapiro-Wilk, Q-Q plots) -- transform (log) or go non-parametric.

The test menu: t-test (two groups), ANOVA (3+ groups; post-hoc Tukey), chi-square (categories), correlation vs regression (association vs prediction), Mann-Whitney/Kruskal-Wallis (non-parametric), and survival analysis (telemetry data!). The exam's decision question: 'which test for this data?' -- decide by groups and data type. Report: test statistic, df, p-value, effect size (Cohen's d -- p-values aren't enough!), and CIs.

Multivariate and modern: PCA (morphometrics -- the shape space), cluster analysis (community ecology), GLMs (counts with Poisson!), and molecular phylogenetics (maximum likelihood trees -- bootstrap support). Software: R (the lingua franca -- learn it!), SPSS, PAST (paleontology's gift to all). Reproducibility: script everything, share data (Dryad/GBIF) -- the open-science mandate.

Key Terms & Definitions

- Data types — Categorical, ordinal, continuous.
- Effect size — Beyond p-values; Cohen's d.
- GLM — Generalized linear models; counts.
- Reproducibility — Script it; share data.

Example / Illustration

- Fish lengths in 4 ponds (continuous, normal): one-way ANOVA + Tukey; parasite presence/absence by site (categorical): chi-square; beak size vs seed size (two continuous): regression -- decide by structure.

Lesson Summary

- Data type dictates the test.
- Report effect sizes, not just p.
- Script everything; share data.

Exam Pointers — Very Important

★ Choose and justify tests for three datasets -- the statistics decision drill.

Lesson 5: Taxonomic, Molecular, and Lab Methods

Learning Objectives

- Practice taxonomy
- Use molecular methods
- Build phylogenies
- Study physiology/behavior

Taxonomy: the descriptive bedrock -- collecting (nets, traps, permits!), preserving (ethanol, formalin -- safety!), vouchering (museum deposition -- the permanent record), and describing (morphometrics + DNA barcoding -- COI gene; integrative taxonomy). Pakistan's fauna: under-described (new species yearly -- the frontier!). Keys and revisions: the taxonomist's craft.

Molecular methods: DNA extraction, PCR (primers, annealing -- the troubleshooting art), sequencing (Sanger vs NGS), and phylogenetics (alignment -- MUSCLE/MAFFT; model selection; ML/Bayesian trees; outgroups root the tree). Applications: cryptic species (the frog that was three), diet (fecal DNA), and wildlife forensics (the poached pangolin's origin).

Physiology and behavior: respirometry, hormone assays (ELISA), telemetry (GPS collars -- movement ecology), and ethograms (behavioral catalogs; focal vs scan sampling -- Altmann's methods). Lab safety: chemicals, zoonoses (field PPE!), and waste. The exam: 'design a study combining morphology and molecules' -- integrative thinking.

Key Terms & Definitions

- DNA barcoding — COI; species identification.
- Integrative taxonomy — Morphology + molecules.
- Vouchering — Museum deposition.
- Ethogram — Behavioral catalog; Altmann.

Example / Illustration

• Suspected new gecko: morphometrics (scale counts, proportions) + COI barcoding + phylogeny (ML tree, bootstrap) + voucher in the museum -- description no one can dispute.

Lesson Summary

• Describe + barcode + voucher.

• Molecules reveal cryptic diversity.

• Integrate methods; don't silo.

Exam Pointers — Very Important

★ Design an integrative taxonomy study -- the methods-synthesis question.

Lesson 6: Ecology and Conservation Research

Learning Objectives

• Study populations

• Assess extinction risk

• Research conservation

• Link science to policy

Population ecology: abundance (mark-recapture, distance sampling), demography (life tables -- lx, mx; the Leslie matrix), and population viability analysis (PVA -- extinction risk modeling; the conservation tool). Community: diversity indices (Shannon, Simpson -- know what they weight), ordination (NMDS -- the community map), and food webs (stable isotopes -- who eats whom, chemically).

Conservation research: threatened-species assessments (IUCN Red List criteria -- the global standard; Pakistan's assessors needed!), protected-area effectiveness (before-after comparisons), human-wildlife conflict (leopard-livestock -- the compensation debate), and reintroductions (the science of coming back). Fisheries/aquaculture: stock assessment (CPUE trends), the Indus dolphin's story (rescue to recovery -- Pakistan's conservation icon).

Ecosystem and landscape: habitat fragmentation (patch-corridor-matrix), remote sensing (land-cover change -- the deforestation audit), and climate impacts (range shifts -- the Himalaya's uphill march). Policy link: research must reach managers -- the science-policy gap; write the management summary, not just the paper. The exam: 'design a Red List assessment.'

Key Terms & Definitions

- PVA — Population viability analysis.
- IUCN Red List — Threat-assessment standard.
- Shannon / Simpson — Diversity indices.
- Science-policy gap — Research must reach managers.

Example / Illustration

- Indus dolphin: tiny range (one river!), declining -- criteria B (restricted range) + C (small declining population) -> Endangered; the rescue program's monitoring as the response.

Lesson Summary

- Count, model, assess, act.
- Red List: the global triage.
- Write for managers too.

Exam Pointers — Very Important

★ Design an IUCN Red List assessment for a Pakistani species -- the conservation practical.

Lesson 7: Scientific Writing

Learning Objectives

- Structure IMRaD
- Write abstracts and titles
- Format the thesis
- Avoid writing sins

IMRaD: Introduction (the funnel -- broad context to the gap to the question), Methods (reproducible detail -- someone must repeat you), Results (facts only -- tables/figures carry them), and Discussion (meaning -- answer the question, compare with literature, admit limits, propose next). The Abstract: the 250-word ambassador -- written last. Titles: specific and searchable ('Gill ATPase activity in Labeo rohita under...', not 'A study of fish').

The thesis: VU's ZOO620 deliverable -- chapters (Introduction, Literature Review, Methodology, Results, Discussion, Conclusion, References), formatting per the manual, and the viva (defend choices: 'why this test? why this n?'). Writing craft: one idea per paragraph, topic sentences, past tense for your work, present for established knowledge; figures before text describes them; tables self-contained (legends!).

Common sins: results in the introduction, discussion repeating results, methods too vague to repeat, and reference chaos (Zotero from day one!). The exam: 'structure a

paper from these notes' -- IMRaD assembly under time.

Key Terms & Definitions

- IMRaD — Introduction, Methods, Results, Discussion.
- Viva — Thesis defense; justify choices.
- Self-contained tables — Legends explain fully.
- Zotero — Reference manager; start day one.

Example / Illustration

- Abstract formula: context (1 sentence) + gap (1) + methods (2) + key result (2) + meaning (1) = 7 sentences, ~200 words; write it last, revise it most.

Lesson Summary

- Funnel in; facts in results; meaning in discussion.
- Abstract last, revised most.
- Reproducible methods or it didn't happen.

Exam Pointers — Very Important

★ Assemble IMRaD from jumbled sections -- the writing practical.

Lesson 8: Publishing and Peer Review

Learning Objectives

- Choose journals
- Navigate peer review
- Detect predatory journals
- Assign authorship ethically

The journal landscape: international (Zootaxa for taxonomy -- the describer's journal; Journal of Animal Ecology; Molecular Phylogenetics and Evolution), Pakistani (Pakistan Journal of Zoology -- HEC-recognized; Punjab University Journal of Zoology), and the impact-factor game (know it, don't worship it). Choosing: scope fit first, then audience, then metrics; open access (the visibility-fee tradeoff).

Peer review: submit -> editor -> reviewers (2-3) -> revise/resubmit -> accept; responding to reviewers (point-by-point, polite even when they're wrong -- 'we thank the reviewer...' then rebut with evidence). Rejection: normal (revise and resubmit elsewhere -- the paper finds its home). Predatory journals: the traps -- fake impact factors, 3-day 'peer review', spam invitations; checks (Think-Check-Submit; HEC's recognized list; DOAJ).

Authorship ethics: who qualifies (ICMJE criteria -- substantial contribution + drafting + approval), order (first = lead, last = senior/supervisor), and acknowledgments vs

authorship. The exam: 'spot the predatory journal' -- red flags drill.

Key Terms & Definitions

- Impact factor — Know it; don't worship it.
- Revise and resubmit — The normal path.
- Predatory journals — Fake metrics; fast 'review'.
- ICMJE criteria — Authorship standards.

Example / Illustration

- 'Dear Dr., publish in 7 days, $500, Impact Factor 8.2 (Global Impact Factor)' -- spam salutation, impossible speed, fake metric: predatory on all counts; check HEC/DOAJ instead.

Lesson Summary

- Scope fit beats impact factor.
- Polite rebuttals win revisions.
- Think-Check-Submit before paying.

Exam Pointers — Very Important

★ Evaluate three journal invitations for predatory signs -- the red-flag drill.

Lesson 9: Presentations and Defense

Learning Objectives

- Give conference talks
- Design posters
- Defend in viva
- Communicate publicly

Conference talks: the 10-minute story -- one message, three points, figures big enough to read from the back; the 'tell them' structure (tell them what you'll say, say it, tell them what you said); handling questions ('that's beyond our data, but...'). Posters: the 3-minute poster -- title readable at 3 meters, minimal text, QR code to the paper; stand by it, don't read it.

The viva and defense: know your methods cold (every choice justified), anticipate ('why not X?'), admit limits gracefully ('our sample was limited to...; future work should...'), and bring the thesis (tabbed!). Outreach: the 3-minute thesis (3MT), popular articles (Dawn's science pages), and school talks -- the researcher as communicator (funders notice!).

Visuals: graphs (axes labeled, units, error bars -- always!), photos (scale bars -- the ruler in the frame!), and maps (north arrow, scale). The exam: 'critique this figure' -- hunt missing labels, 3D pie charts (never!), and truncated axes.

Key Terms & Definitions

- 3MT — Three-minute thesis.
- Error bars — Always; show variation.
- Scale bars — The ruler in every photo.
- QR code poster — Link to the full paper.

Example / Illustration

- The 3D pie chart of diet composition: distorted, unreadable -- replace with a bar chart, error bars, n in the legend; the 30-second fix that saves a talk.

Lesson Summary

- One message, three points, big figures.
- Admit limits; justify choices.
- Scale bars, error bars, labeled axes.

Exam Pointers — Very Important

★ Critique a conference slide/poster -- the visuals practical.

Lesson 10: Grants and Funding

Learning Objectives

- Find funding sources
- Write proposals
- Budget realistically
- Pass ethical review

Pakistani funding: HEC (NRPU -- National Research Program for Universities; the main grant), PSF (Pakistan Science Foundation), PARB (agriculture), and university ORICs (the local office -- start there!). International: Rufford (small conservation grants -- the classic first grant!), National Geographic, Darwin Initiative, and the small-grants ladder (start small, build track record).

Proposal anatomy: title, abstract, background (the gap), objectives (SMART), methodology (detailed -- reviewers hunt vagueness), budget (justified line by line -- the per-diem realism!), timeline (Gantt chart), expected outcomes, and CVs. The reviewer's lens: significance, feasibility, and value for money -- write to those three. Common kills: vague methods, inflated budgets, and ignoring the funder's priorities.

Budget craft: equipment vs consumables vs travel vs personnel; institutional overheads; and the audit trail (receipts! -- HEC audits). Ethics/permits section: the committee expects the 3Rs paragraph and permit numbers. The exam: 'draft a one-page concept note' -- the funding practical.

Key Terms & Definitions

- NRPU — HEC's main research grant.
- Rufford — The classic first conservation grant.
- SMART objectives — Specific, measurable, achievable...
- Concept note — The one-page pitch.

Example / Illustration

- Concept note: 'Assessing freshwater turtle bycatch in Punjab's headworks' -- gap (no data), method (fisher interviews + net surveys, 6 months), budget (Rs. 800,000 itemized), outcome (bycatch mitigation plan) -- one page, fundable.

Lesson Summary

- Start at the ORIC; climb the grants ladder.
- Significance, feasibility, value -- the lens.
- Vague methods kill proposals.

Exam Pointers — Very Important

★ Draft a concept note for a Rufford-style small grant -- the funding practical.

Lesson 11: Fieldwork Logistics

Learning Objectives

- Plan expeditions
- Manage field safety
- Handle zoonoses
- Keep field data

Expedition planning: permits (wildlife departments, protected-area authorities -- apply months ahead!), team (roles: leader, medic, driver-mechanic), gear (traps, preservatives, GPS, first aid -- the checklist), and the risk assessment (the document funders/ethics want). Field seasons: monsoon vs winter -- phenology dictates timing (breeding surveys in spring!).

Safety: the field's non-negotiables -- never alone (buddy system), communication (satellite phone where no signal), water/food discipline, venomous-fauna protocols (the snakebite plan -- hospital mapped in advance!), and the weather watch (flash floods in nullahs). Zoonoses: gloves, masks, hand hygiene -- the field PPE. Cultural: respect local communities (permissions, hiring local guides -- the ethical and practical win).

Data in the field: waterproof notebooks (pencil!), daily backups (photos of datasheets), GPS waypoints logged, and specimens labeled immediately (date, locality, collector -- the unlabeled jar is worthless!). The exam: 'plan a 10-day survey' -- logistics under constraints.

Key Terms & Definitions

- Risk assessment — The safety document.
- Buddy system — Never fieldwork alone.
- Phenology — Timing by life cycles.
- Field labels — Date, locality, collector -- always.

Example / Illustration

- The unlabeled jar: a 'newt' in ethanol, no data -- scientifically worthless; the lesson: label in the field (date, GPS, habitat, collector) or lose the science.

Lesson Summary

- Permits months ahead; phenology sets timing.
- Buddy system; snakebite plan; backups.
- Label now or lose it.

Exam Pointers — Very Important

★ Plan a 10-day herpetofaunal survey -- the logistics practical.

Lesson 12: Data Management and Open Science

Learning Objectives

- Manage data
- Apply FAIR
- Use biodiversity databases
- Practice open science

Data management: the plan (DMP -- funders ask!), file naming (YYYYMMDD_site_species_v01 -- no 'final_final.xlsx'!), and the 3-2-1 backup (3 copies, 2 media, 1 offsite). Databases: spreadsheets done right (one row per observation; no merged cells -- the analysis-killers), then SQLite/R for scale. Metadata: the README that explains every column -- future-you will thank present-you.

Open science: share data (GBIF for occurrences -- Pakistan's data gap is a global loss!; Dryad/Zenodo for datasets), preprint (bioRxiv -- stake your claim), and open code (GitHub). FAIR principles (Findable, Accessible, Interoperable, Reusable) -- the exam's acronym. The reproducibility crisis: psychology's lesson for zoology -- preregister (OSF), share all.

Biodiversity informatics: GBIF (the global occurrence database -- query it before fieldwork!), BOLD (barcoding database), GenBank (sequences), and the taxonomic backbone (Catalogue of Life). Pakistan's opportunity: digitizing museum holdings -- the low-hanging, high-impact project. The exam: 'make a dataset FAIR.'

Key Terms & Definitions

- 3-2-1 backup — 3 copies, 2 media, 1 offsite.
- FAIR — Findable, Accessible, Interoperable, Reusable.
- GBIF / BOLD — Occurrence / barcode databases.
- Preregistration — OSF; beat the crisis.

Example / Illustration

- 'final_final_v3.xlsx' with merged cells and color-coded species: unmerge, one-row-per-observation, species as a column, ISO dates, README -- the 20-minute rescue.

Lesson Summary

- Name files sanely; back up thrice.
- Share via GBIF/Dryad/GitHub.
- Pakistan: digitize the museums!

Exam Pointers — Very Important

★ Fix a messy spreadsheet into analysis-ready data -- the data practical.

Lesson 13: Museums, Collections, Careers

Learning Objectives

- Use museum collections
- Propose collections research
- Digitize holdings
- Plan research careers

Museums: Pakistan's holdings (Pakistan Museum of Natural History, Islamabad -- the national collection; university museums), curation (cataloging, pest control -- dermestids vs dermestids!), and digitization (imaging, databasing -- the GBIF pipeline). Type specimens: the name-bearers -- why vouchering matters (the ZOO620 loop closes!). Loans and visits: the taxonomist's network.

Collections-based research: morphometrics from drawers (the 100-year time series!), stable isotopes from feathers (diet through decades), ancient DNA (museum skins' genetics), and the discovery rate (new species hiding in cabinets -- the 'shelf life' of specimens). The exam: 'propose a museum-based project.'

Careers: academia (lecturer to professor -- the HEC tenure track), wildlife departments (the applied path), NGOs (WWF-Pakistan, Snow Leopard Foundation -- the conservation career), environmental consultancies (EIA work -- the private sector), and science communication. The researcher's portfolio: papers + grants + students + impact -- build all four from ZOO620 onward. Closing: the thesis is the first brick -- lay it straight.

Key Terms & Definitions

- Type specimens — The name-bearing vouchers.
- Dermestid control — Pest management in collections.
- Shelf discoveries — New species in old cabinets.
- Tenure track — HEC's academic ladder.

Example / Illustration

- PMNH sparrow skins, 1970-2020: beak measurements vs climate data -- the 50-year dataset no field season can buy; digitize, measure, publish -- the drawer as time machine.

Lesson Summary

- Drawers hold time series.
- Vouchering then, discovery now.
- Build the four-part portfolio.

Exam Pointers — Very Important

★ Propose a museum-based research project -- the collections practical.

Lesson 14: Revision: Research Master Drill

Master drill (two per lesson): (1) 3Rs; (2) FINER; (3) H0/H1; (4) pseudoreplication; (5) BACI; (6) Lincoln-Petersen; (7) test selection; (8) effect sizes; (9) DNA barcoding; (10) IMRaD; (11) abstract formula; (12) predatory red flags; (13) 3MT; (14) NRPU/Rufford; (15) concept note; (16) buddy system; (17) 3-2-1 backup; (18) FAIR; (19) type specimens. Design drills: (a) FINER a question; (b) critique a design; (c) choose tests; (d) plan a survey; (e) draft a concept note. Viva prep: justify every methods choice aloud. Final: the thesis is the first brick -- lay it straight.