IUCN/SSC Small Carnivore Specialist Group

ARTICLE

Toward a better understanding of the Japanese Marten *Martes melampus* diet

Masumi HISANO

Faculty of Natural Resources Management, Lakehead University, 955 Oliver Rd., Thunder Bay, ON P7B 5E1, Canada

Correspondence:
Masumi Hisano
mhisano@lakeheadu.ca

Associate editor:
Daniel Willcox

http://www.smallcarnicoreconservation.org
ISSN 1019-5041

Abstract

Examining diet is essential to understanding the ecology and life history of animals. Martens (*Martes*, Mustelidae: Carnivora) are typical generalist feeders; however, the feeding ecology of Asian martens is less understood compared to those in Europe and North America. On the basis of previous literature reviews, I expose here current gaps in our knowledge of the diet of the Japanese Marten *Martes melampus* and identify future research requirements. This paper addresses the lack of efforts in measuring food availability and quantifying the Marten diet by biomass/volume metrics, which prevents us from examining optimal foraging theory, a macronutrient framework and interspecific competition with other sympatric carnivores. There are also knowledge gaps in dietary differences between sexes, which could be associated with sexual size dimorphism. Moreover, researchers need to be aware of how environmental changes, including urbanisation and global climate change, may affect the feeding behaviour of the Japanese Marten. Enhancing studies of the Japanese Marten and other Asian *Martes* species by considering these perspectives will allow us to formulate a comprehensive understanding of adaptive foraging behaviour in Holarctic martens.

Keywords: Japanese Marten, *Martes melampus*, Mustelidae, carnivore, faeces, feeding ecology, food habits

Introduction

Accumulating dietary information is essential to improve our understanding of species ecology and life history (Carr & Macdonald 1986, Machovsky-Capuska *et al.* 2016). Many species of generalist feeders have evolved adaptive strategies to utilise diverse foods. Martens (*Martes* spp.) are typical opportunistic generalists whose food composition is associated with geo-climatic factors (e.g., Zhou *et al.* 2011a). The diets of Pine Martens *Martes martes* and Stone Martens *M. foina* in Europe and the American Marten *M. americana* and the Pacific Marten *M. caurina* in North America have been extensively studied and the findings systematically synthesised (Zalewski 2004, Papakosta 2014, Zhou *et al.* 2011a, Remonti *et al.* 2016). However, the feeding ecology of Asian martens has been less studied and is less understood (see Hisano *et al.* 2019, Tsuji et al. 2019) despite the importance of this knowledge in aiding the development of conservation and management policy (e.g., Caryl *et al.* 2012, Newsome *et al.* 2016). This paper focuses on dietary studies of the Japanese Marten *M. melampus*, a species endemic to the main islands of Japan.

The Japanese Marten is listed as Least Concern on the IUCN Red List of Threatened Species (Abramov *et al.* 2015); nonetheless, some of its local populations require conservation efforts. In Japan's national and regional Red Lists, for example, Marten

populations are listed as Nearly Threatened in Gunma Prefecture (2012), Aichi Prefecture (2015) and Tsushima Island (Ministry of the Environment 2017) because they are influenced by habitat loss and degradation as a consequence of intensive deforestation and plantation establishment, as well as urbanisation (Tatara & Doi 1994, Proulx *et al.* 2004, Abramov *et al.* 2015). Understanding the ecology and life history of the Japanese Marten is fundamentally important to inform conservation and management policy planners and practitioners (Watt *et al.* 1996, Proulx *et al.* 2004).

Regional studies have shown that the primary foods of the Japanese Marten are small mammals (mainly rodents), fruits (berries) and invertebrates, with occasional exploitation of birds, reptiles, amphibians and carcasses of ungulates (see syntheses by Hisano & Deguchi 2018, Hisano *et al.* 2019, Tsuji *et al*. 2019). However, most of dietary studies of the Japanese Marten have not produced more than simple dietary descriptions and many aspects of its feeding ecology remain unexplored. In order to facilitate studies of the Japanese Marten's diet and its ecological role, here I expose gaps in our knowledge of its diet, which I organise in terms of technical and biological concerns. I then identify future study requirements, on the basis of previous literature reviews (Hisano & Deguchi 2018; Hisano *et al.* 2019).

Technical concerns

Visual/olfactory techniques for faecal identification

Japanese Marten dietary surveys have been limited by the researchers' skills in distinguishing Marten scats from those of other sympatric carnivores (see Davison *et al.* 2002, Kurose *et al.* 2005). For example, ca. 20% of Pine Marten faeces were misidentified as confounded with fox faeces in a study in Scotland (Davison *et al.* 2002, Baines *et al.* 2013). However, a recent study comparing DNA diagnostic and visual/olfactory techniques found that visual/olfactory identification techniques were >95% reliable for fresh (unbroken and odoriferous) scats, without recourse to expensive DNA diagnostic techniques (Hisano *et al.* 2017). This is promising for future studies of the Japanese Marten.

Identifying food items

Misidentifying food items or poor knowledge of contents in samples leads to incorrect findings in dietary studies. Each scientist should improve his or her identification skills, for example, by collecting food specimens in the field (see Hisano et al. 2016, 2017). Regardless, food identification abilities will differ among researchers.

More attention must be paid to the taxonomic level of food item identification that is appropriate for comparing or compiling studies. If a study aims to describe local characteristics of Marten diet, it would be necessary to identify food items at species level.

However, for the purpose of general dietary examinations, class level identification of food categories may be suitable.

Dietary metrics

Standardised dietary metrics are important for further syntheses and meta-analyses. Dietary studies of the Marten should report the total number of food items used for calculating frequency of occurrence (FO) or relative frequency of occurrence (RFO; see Zhou et al. 2011b), as well as with the number of stomachs/faeces examined per season (Adachi *et al.* 2016). A lack of such data precluded the inclusion of eight annual and/or seasonal studies in a previous meta-analysis (Hisano *et al.* 2019), which reduced statistical power. This is particularly problematic when looking at the utilisation of specific species – for example, the consumption rate of endangered birds or nuisance foraging on domestic crops – and when performing geographic/climate analyses (*cf.* Zhou *et al.* 2011a; Tsuji et al. 2019).

No studies of the Japanese Marten have measured quantities of food consumed, which is crucial for the systematic understanding of their foraging strategy. Dietary switching in the Japanese Marten is often based on the authors' speculation (e.g., Hisano *et al.* 2017), whereas studies of switching in other marten species – for example, the American Marten (Thompson & Colgan 1990), the Yellow-throated Marten *Martes flavigula* (Zhou *et al.* 2011b) and the Pine Marten (Caryl *et al.* 2012) – has been based on reliable information about fluctuating environmental resource abundance.

Moreover, biomass-based methods of assessing Japanese Marten diet, e.g., the percentage of dry weight (Kondo 1980, Yamagishi 1990, Hisano *et al.* 2017), have rarely been employed, with studies relying on frequency-based methods. Biomass calculations, which introduce less potential for misinterpreting data, are proposed as the most accurate evaluation of carnivore diet (Klare *et al.* 2011). These data would enable the quantitative testing of Charnov's (1976) optimal foraging theory (*cf.* Zhou *et al.* 2011b, Thompson & Colgan 1990) and the dietary generalist–specialist distinction within the macronutrient framework (Machovsky-Capuska *et al.* 2016) with energy-based metrics (Remonti *et al.* 2016).

Biological concerns

Regional biases in survey effort

Although the Japanese Marten has an extensive distribution across Japan (Abramov *et al.* 2015), their diet is still unknown from large regions, such as Tohoku Region (northern Japan) and Chugoku/Shikoku Region (western Japan). More effort is needed to gather information about Japanese Marten ecology in these unexplored regions. Although a previous meta-analysis (Hisano *et al.* 2019) revealed that the thermal forest zone could generally determine

whether Martens were more carnivorous/insectivorous or more frugivorous/omnivorous, we still need to enhance the quantity and quality of dietary studies in several regions in Japan.

Urban Martens

The Japanese Marten inhabits not only forested areas but also suburban residential areas. Here Martens are known to scavenge human refuse and even to den and reproduce in attics (Watanabe 2016, ASWAT 2017, Wildlife Damage Controlling Society 2017), as do Stone Martens in Europe (e.g., Hisano *et al.* 2016). Examining the diet of suburban Japanese Martens may provide useful information for non-forest populations and aid in mitigating human–wildlife conflict (see Bateman & Fleming 2012; *cf.* Czernik *et al.* 2016, Hisano *et al.* 2016 for Stone Martens).

Marten diet under climate change

Few studies report Japanese Marten diet from sub-alpine regions (>1500 m asl) compared to temperate regions, even though the former is an important part of their population range (Ueuma *et al*. 2005, Hisano *et al.* 2017). The logistical difficulties and safety concerns that result from severe winter weather typically constrain sub-alpine studies to summer (Ueuma *et al.* 2005, Hisano *et al.* 2017). Nonetheless, monitoring Marten diet in highland habitats and comparing the findings with those from lowland habitats within the same study area (Suzuki 1977, Hisano *et al.* 2017, see also Hisano *et al.* 2016) are important because the zonation of species in relation to ecosystem composition is particularly vulnerable to climate change along elevational gradients in mountain ranges (Pauli *et al.* 2012). For example, Zhou *et al.* (2013) report that an unprecedented snow storm significantly impacted the diet of Yellow-throated Martens and other seed-dispersing species in central China. In recent years, Japan has also experienced regional climate extremes, such as record torrential rain and heavy snow (Tai *et al.* 2012, Nakai 2015), which may affect Japanese Marten food supply (e.g., fruit fertilisation). Shifts in forest type/composition with temperature warming are being observed across the Japanese archipelago, particularly at biome boundaries (Suzuki *et al.* 2015). As food diversity and availability alters, so too might the diet of Japanese Martens. It should also be noted that shifts in Marten diet can be attributed to fluctuations of food availability due to seasonality (a short-term factor) and climate change (long-term factors). Future studies should seek to disentangle these factors to better understand these abiotic effects on Marten diet.

Interspecific competition with sympatric carnivores

Martens potentially compete with other sympatric carnivores for food resources. Within a given study area, several studies have compared food habits of the Japanese Marten with other sympatric carnivores, such as Red Foxes *Vulpes vulpes* (Kitahara 1985, Kondo 1980,

Yamamoto 1994, Ueuma *et al.* 2005, Koike *et al.* 2008, 2012, Hisano *et al.* 2017); Raccoon Dogs *Nyctereutes procyonoides* (Yamamoto 1994, Koike *et al.* 2008, 2012, Takatsuki *et al.* 2018), Japanese Badgers *Meles anakuma* (Yamamoto 1994, Koike *et al.* 2008, 2012), Japanese Weasels *Mustela itatsi* (Tsuji *et al.* 2011), Siberian Weasels *M. sibirica* (Tatara & Doi 1994), Stoats *M. erminea* (Ueuma 2005), Leopard Cats *Prionailurus bengalensis* (Tatara & Doi 1994), and Asiatic Black Bears *Ursus thibetanus* (Koike *et al.* 2008, 2012). The dietary niche of Martens substantially overlaps with *V. vulpes* and *N. procyonoides* although Martens showed higher trophic diversity than these species (Yamamoto 1994; Hisano *et al.* 2017). In order to further understand mechanisms of food resource partitioning (or interspecific competition) among sympatric Japanese carnivores, dietary comparison and food availability data are necessary (e.g., Carvalho & Gomes 2004).

Sexual comparisons

Though sexual dimorphism can be substantial in small mustelids (Moors 1980, Noonan *et al.* 2016), leading to differences in diet (Macdonald & Newman 2017), there is a paucity of studies contrasting Japanese Marten diet between sexes. Such studies exist for such *Martes* species as Stone Marten (Loy *et al.* 2004, Bakaloudis *et al.* 2012, Hisano *et al.* 2013, 2014), Pine Marten (Zalewski 2007), American Marten (Nagorsen *et al.* 1989, Bull 2000, Hales *et al.* 2008) and Sable *Martes zibellina* (Dubinin 2010). Cooperative work with local hunters (e.g., Hisano *et al.* 2013, 2014) or collecting road-kill samples (Okawara *et al.* 2018; see also Iwama *et al.* 2017) will enable us to test the effects of sexual size dimorphism (Moors 1980; Noonan *et al.* 2014) on the Japanese Marten diet, which can also be combined with corporal and cranial measurements (see Loy 2004 for Stone Marten). Only two studies (Ohtsu 1972, Okawara *et al.* 2018) have examined the Japanese Marten diet by stomach content analysis. Considering the difficulty in obtaining large numbers of dead Marten bodies in Japan (where hunting is not a popular sport and Martens are often subject to conservation), developing stable isotope techniques for dietary analysis (see Manlick *et al.* 2017 for the American Marten and the Fisher *Pekania pennanti* would be a better approach for the Japanese Marten.

Conclusion

Dietary studies of Asian martens, including the Japanese Marten, are lagging behind those of other *Martes* species in Europe and North America. This paper has proposed ways to expand and improve research into the feeding ecology of the Japanese Marten. The issues raised here are relevant to the other Asian martens (subgenus *Charronia*: *M. flavigula* and *M. gwatkinsii*), for which ecological information is even scantier.

Acknowledgements

I thank Dr. Shota Deguchi (Fukui City Museum of Natural History) for his assistance in collecting literature. I am also grateful to Dr. Daniel Willcox, Dr. Helle V. Goldman and the two anonymous reviewers for their helpful comments and suggestions to improve the manuscript.

References

Abramov, A. V., Kaneko, Y. & Masuda, R. 2015. *Martes melampus*. The IUCN Red List of Threatened Species 2015: e.T41650A45213228. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T41650A45213228.en. Downloaded on 23 January 2018.

Adachi, T., Kuwahara, Y. & Takatsuki, S. 2016. [A long-term study of the food habits of the Japanese Marten in northern Kyushu, Japan, with reference to the increased population of Sika Deer.] *Japanese Journal of Conservation Ecology* 21: 203-217. (In Japanese.)

Aichi Prefecture 2015. [Red List Aichi 2015.] http://www.pref.aichi.jp/kankyo/sizen-ka/shizen/yasei/redlist/redlist_2015.pdf. Downloaded on 14 November 2017. (In Japanese.)

ASWAT 2017. [The Weasel Management Company ASWAT.] http://www.e-aswat.com. Downloaded on 05 November 2017. (In Japanese.)

Baines, D., Aebischer, N., Macleod, A. & Woods, J. 2013. Pine Marten *Martes martes* and Red Fox *Vulpes vulpes* sign indices in Scottish forests: population change and reliability of field identification of scats. *Wildlife Biology* 19: 490-495.

Bakaloudis, D. E., Vlachos, C. G., Papakosta, M. A., Bontzorlos, V. A. & Chatzinikos, E. N. 2012. Diet composition and feeding strategies of the Stone Marten (*Martes foina*) in a typical Mediterranean ecosystem. *The Scientific World Journal* 2012: article no. 163920.

Bateman, P. W. & Fleming, P. A. 2012. Big city life: carnivores in urban environments. *Journal of Zoology* 287: 1-23.

Bull, E. L. 2000. Seasonal and sexual differences in American Marten diet in northeastern Oregon. *Northwest Science* 74: 186-191.

Carr, G. M. & Macdonald, D. W. 1986. The sociality of solitary foragers: a model based on resource dispersion. *Animal Behaviour* 34: 1540-1549.

Carvalho, J. C. & Gomes, P. 2004. Feeding resource partitioning among four sympatric carnivores in the Peneda-Gerês National Park (Portugal). *Journal of Zoology* 263: 275-283.

Caryl, F. M., Raynor, R., Quine, C. P. & Park, K. J. 2012. The seasonal diet of British Pine Marten determined from genetically identified scats. *Journal of Zoology* 288: 252-259.

Charnov, E. L., Orians, G. H. & Hyatt, K. 1976. Ecological implications of resource depression. *The American Naturalist* 110: 247-259.

Czernik, M., Kowalczyk, R. & Zalewski, A. 2016. Spatio-temporal variation of predator diet in a rural habitat: Stone Martens in the villages of Białowieża forest. *Mammal Research* 61: 187-196.

Davison, A., Birks, J. D., Brookes, R. C., Braithwaite, T. C. & Messenger, J. E. 2002. On the origin of faeces: morphological versus molecular methods for surveying rare carnivores from their scats. *Journal of Zoology* 257: 141-143.

Dubinin, E. A. 2010. On sexual dimorphism in the winter diet of the sable (*Martes zibellina* L.). *Russian Journal of Ecology* 41: 244-248.

Gunma Prefecture 2012. [Red List of the Animals in 2012.] http://www.pref.gunma.jp/contents/000219298.pdf. Downloaded on 14 November 2017. (In Japanese.)

Hales, A. L., Belant, J. L. & Bird, J. 2008. Effects of sex and age on winter diet of American Martens in Michigan. *Ohio Journal of Science* 108: 60-64.

Hisano, M. & Deguchi, S. 2018. Reviewing frugivory characteristics of the Japanese Marten (*Martes melampus*). *Zoology and Ecology* 28: 10-20.

Hisano, M., Hoshino, L., Kamada, S., Masuda, R., Newman, C. & Kaneko, Y. 2017. A comparison of visual and genetic techniques for identifying Japanese Marten scats enabling diet examination in relation to seasonal food availability in a sub-alpine area of Japan. *Zoological Science* 34: 137-146.

Hisano, M., Newman, C., Deguchi, S. & Kaneko, Y. 2019. Thermal forest zone explains regional variations in the diet composition of the Japanese Marten (*Martes melampus*). *Mammalian Biology* 95: 173-180.

Hisano, M., Raichev, E. G., Peeva, S., Georgiev, M. D., Tsunoda, H., Masuda, R. & Kaneko, Y. 2014. Notes on autumn–winter stomach contents of the Stone Marten (*Martes foina*) in the Balkan Mountains, central Bulgaria. *ZooNotes* 56: 1-6.

Hisano, M., Raichev, E. G., Peeva, S., Tsunoda, H., Newman, C., Masuda, R., Georgiev, D. & Kaneko, Y. 2016. Comparing the summer diet of Stone Martens (*Martes foina*) in urban and natural habitats in central Bulgaria. *Ethology Ecology and Evolution* 28: 295-311.

Hisano, M., Raichev, E. G., Tsunoda, H., Masuda, R. & Kaneko, Y. 2013. Winter diet of the Stone Marten (*Martes foina*) in central Bulgaria. *Mammal Study* 38: 293-298.

Iwama, M., Yamazaki, K., Matsuyama, M., Hoshino, Y., Hisano, M., Newman, C. & Kaneko, Y. 2017. Masked Palm Civet *Paguma larvata* summer diet differs between sexes in a suburban area of central Japan. *Mammal Study* 42: 185-190.

Kitahara, T. 1985. [Diet of mammals examined by faecal analysis.] Pp. 25-36 in [*Reports of the habitat environment assessment for the Japanese rock ptarmigan between 1978 and 1983.*] Toyama Prefecture, Toyama, Japan. (In Japanese.)

Klare, U., Kamler, J. F. & Macdonald, D. W. 2011. A comparison and critique of different scat-analysis methods for determining carnivore diet. *Mammal Review* 41: 294-312.

Koike, S., Morimoto, H., Goto, Y., Kozakai, C. & Yamazaki, K. 2008. Frugivory of carnivores and seed dispersal of fleshy fruits in cool-temperate deciduous forests. *Journal of Forest Research* 13: 215-222.

Koike, S., Morimoto, H., Goto, Y., Kozakai, C. & Yamazaki, K. 2012. Insectivory by five sympatric carnivores in cool-temperate deciduous forests. *Mammal Study* 37: 73-83.

Kondo, K. 1980. [Food habits of the Red Fox (*Vulpes vulpes japonica*) and the Japanese Marten (*Martes melampus melampus*).] *Osaka Kyoiku University Repository III Natural Science* 29: 19-23. (In Japanese.)

Kurose, N., Masuda, R. & Tatara, M. 2005. Fecal DNA analysis for identifying species and sex of sympatric carnivores: a noninvasive method for conservation on the Tsushima Islands, Japan. *Journal of Heredity* 96: 688-697.

Loy, A., Spinosi, O. & Carlini, R. 2004. Cranial morphology of *Martes foina* and *M. martes* (Mammalia, Carnivora, Mustelidae): the role of size and shape in sexual dimorphism and interspecific differentiation. *Italian Journal of Zoology* 71: 27-34.

Macdonald, D. W & Newman, C. 2017. Musteloid sociology: the grass-roots of society. Pp. 167-188 in Macdonald, D. W., Newman, C. & Harrington, L. (eds) *The biology and conservation of wild musteloids*. Oxford University Press, Oxford, UK.

Machovsky-Capuska, G. E., Senior, A. M., Simpson, S. J. & Raubenheimer, D. 2016. The multidimensional nutritional niche. *Trends in Ecology and Evolution* 31: 355-365.

Manlick, P. J., Woodford J. E., Zuckerberg B. & Pauli J. N. 2017. Niche compression intensifies competition between reintroduced American Martens (*Martes americana*) and Fishers (*Pekania pennanti*). *Journal of Mammalogy* 98: 690-702.

Ministry of the Environment 2017. [Red List 2017.] http://www.env.go.jp/nature/kisho/hozen/redlist/MOEredlist2017.pdf. Downloaded on 14 November 2017. (In Japanese.)

Moors, P. J. 1980. Sexual dimorphism in the body size of mustelids (Carnivora): the roles of food habits and breeding systems. *Oikos* 34: 147-158.

Nagorsen, D. W., Morrison, K. F. & Forsberg, J. E. 1989. Winter diet of Vancouver Island Marten (*Martes americana*). *Canadian Journal of Zoology* 67: 1394-1400.

Nakai, S. 2015. [Variation and distribution of winter snow depth in Japan using 'seasonal snow depth index'.] *Weather* 62: 187-199. (In Japanese.)

Newsome, T. M., Boitani, L., Chapron, G., Ciucci, P., Dickman, C. R., Dellinger, J. A., López-Bao, J. V., Peterson, R. O., Shores, C. R., Wirsing, A. J. & Ripple, W. J. 2016. Food habits of the world's Grey Wolves. *Mammalian Review* 46: 255-269.

Noonan, M. J., Johnson, P. J., Kitchener, A. C., Harrington, L. A., Newman, C. & Macdonald, D. W. 2016. Sexual size dimorphism in musteloids: an anomalous allometric pattern is explained by feeding ecology. *Ecology and Evolution* 6: 8495-8501.

Okawara, Y., Nakanishi, N. & Izawa, M. 2018. Different seasonal diets of the Tsushima Marten *Martes melampus tsuensis* revealed by quantitative assessment of stomach contents. *Mammal Study* 43: 187-198.

Otsu, S. 1972. [Winter food of Japanese Yellow Marten, *Martes melumpus melumpus* (Temminck et Schlegel), in Yamagata Prefecture.] *Japanese Journal of Applied Entomology and Zoology* 16: 75-78. (In Japanese.)

Papakosta, M., Kitikidou, K., Bakaloudis, D. & Vlachos, C. 2014. Dietary variation of the Stone Marten (*Martes foina*): a meta-analysis approach. *Wildlife Biology in Practice* 10: 85-101.

Pauli, H., Gottfried, M., Dullinger, S., Abdaladze, O., Akhalkatsi, M., Alonso, J.L.B., Coldea, G., Dick, J., Erschbamer, B., Fernández-Calzado, R., Ghosn, D., Holten, J.I., Kanka, R., Kazakis, G., Kollár, J., Larsson, P., Moiseev, P., Moiseev, D., Molau, U., Molero-Mesa, J., Nagy, L., Pelino, G., Puşcaş, M., Rossi, G., Stanisci, A., Syverhuset, A. O., Theurillat, J. P., Tomaselli, M., Unterluggauer, P., Villar, L., Vittoz, P. & Ghosn, D. 2012. Recent plant diversity changes on Europe's mountain summits. *Science* 336: 353-355.

Proulx, G., Aubry, K., Birks, J., Buskirk, S., Fortin, C., Frost, H., Krohn, W., Mayo, L., Monakhov, V., Payer, D., Saeki, M., Santos-Reis, M., Weir, R. & Zielinski, W. 2004. World distribution and status of the genus *Martes* in 2000. Pp. 21-76 in Harrison, D. J., Fuller, A. K. & Proulx, G. (eds) *In martens and fishers (Martes) in human-altered environments: an international perspective*. Springer, New York, USA.

Remonti, L., Balestrieri, A., Raubenheimer, D. & Saino, N. 2016. Functional implications of omnivory for dietary nutrient balance. *Oikos* 125: 1233-1240.

Suzuki, S., Miyao, T., Nishizawa, T. & Takada, Y. 1977. [Studies on mammals of the Mt. Kiso–Komagatake, central Japan Alps. III – food habit of the Japanese Marten in upper part of low mountainous zone and the sub-alpine zone of the Mt. Kiso-Komagatake.] *Journal of the Faculty of Agriculture Shinshu University* 14: 147-178. (In Japanese.)

Suzuki, S. N., Ishihara, M. I. & Hidaka, A. 2015. Regional-scale directional changes in abundance of tree species along a temperature gradient in Japan. *Global Change Biology* 21: 3436-3444.

Tai, A., Kubo, N., Hashimoto, A. & Komatsu, T. 2012. Temporal variations of frequency of torrential rain and relationship of human damage and precipitation in past flood and sediment-related disasters. *Journal of Japan Society of Civil Engineers B1* 68: 1057-1062.

Takatsuki, S., Miyaoka, R. & Sugaya, K. 2018. A comparison of food habits between Japanese Marten and Raccoon Dog in western Tokyo with reference to fruit use. *Zoological Science* 35: 68-74.

Tatara, M. & Doi, T. 1994. Comparative analyses on food habits of Japanese Marten, Siberian Weasel and Leopard Cat in the Tsushima islands, Japan. *Ecological Research* 9: 99-107.

Thompson, I. D. & Colgan, P. W. 1990. Prey choice by marten during a decline in prey abundance. *Oecologia* 83: 443-451.

Tsuji, Y., Ito, T.Y. & Kaneko, Y. 2019. Variation in the diets of Japanese Martens *Martes melampus*. *Mammal Review* 49: 121-128.

Tsuji, Y., Tatewaki, T. & Kanda, E. 2011. Endozoochorous seed dispersal by sympatric mustelids, *Martes melampus* and *Mustela itatsi*, in western Tokyo, central Japan. *Mammalian Biology* 76: 628-633.

Ueuma, Y., Tokuno, C. & Tsuji, M. 2005. [Food of Red Fox (*Vulpes vulpes japonica*), Japanese Marten (*Martes melampus melampus*) and Hondo Stoat (*Mustela erminea nippon*) analysed dropping contents on the trails in Mt. Hakusan.] *Annual Reports Hakusan Nature Conservation Center* 32: 31-36. (In Japanese.)

Watanabe, S. 2016. [Shigeki Watanabe's weasel stories: what is the Japanese Marten?] https://ameblo.jp/itachiaswat/entry-12503395056.html. Downloaded on 25 September 2020. (In Japanese.)

Watt, W. R., Baker, J. A., Hogg, D. M., McNicol, J. G. & Naylor, B. J. 1996. Forest management guidelines for the provision of marten habitat. Ontario Ministry of Natural Resources, Sault St. Marie, ON, Canada.

Wildlife Damage Controlling Society 2017. [What is the marten?] http://bungalow8sydney.com/ten.html. Downloaded on 25 September 2020. (In Japanese.)

Yamagishi, M. 1990. Seasonal food habits of the Japanese Marten. *The Bulletin of the Tokyo University Forests* 83: 9-18. (In Japanese.)

Yamamoto, Y. 1994. [Comparative analyses of on food habits of Japanese Marten, Red Fox, badger and Raccoon Dog in Mt. Nyugasa, Nagano Prefecture, Japan.] *Studies of the Natural Environmental Sciences* 7: 45-52. (In Japanese.)

Zalewski, A. 2004. Geographical and seasonal variation in food habits and prey size of European pine martens. Pp. 77-98 in Harrison, D. J., Fuller, A. K. & Proulx G. (eds) *Martens and fishers (Martes) in human-altered environments*. Springer, New York, NY, USA.

Zalewski, A. 2007. Does size dimorphism reduce competition between sexes? The diet of male and female Pine Martens at local and wider geographical scales. *Acta Theriologica* 52: 237-250.

Zhou, Y. B., Newman, C., Buesching, C. D., Zalewski, A., Kaneko, Y., Macdonald, D. W. & Xie, Z. Q. 2011b. Diet of an opportunistically frugivorous carnivore, *Martes flavigula*, in subtropical forest. *Journal of Mammalogy* 92: 611-619.

Zhou, Y. B., Newman, C., Chen, J., Xie, Z. & Macdonald, D. W. 2013. Anomalous, extreme weather disrupts obligate seed dispersal mutualism: snow in a subtropical forest ecosystem. *Global Change Biology* 19: 2867-2877.

Zhou, Y. B., Newman, C., Xu, W. T., Buesching, C. D., Zalewski, A., Kaneko, Y., Macdonald, D. W. & Xie, Z. Q. 2011a. Biogeographical variation in the diet of Holarctic martens (genus *Martes*, Mammalia: Carnivora: Mustelidae): adaptive foraging in generalists. *Journal of Biogeography* 38: 137-147.