Living Tool Diversity (LTD) along Environmental and Population Gradients in Shinan-gun, South Korea

Kyoung-Hoon Yang
Department of Biological Science, Mokpo National University, Korea

Sun-Kee Hong
Institution for Marine and Island Cultures, Department of Liberal Arts, Mokpo National University, Korea

Jae-Eun Kim
Institution for Marine and Island Cultures, Mokpo National University, Korea

Jong-Wook Kim (corresponding author)
Department of Biological Science, Mokpo National University, Korea
keco@mokpo.ac.kr

Publication Information:
Received 9 November 2023, Accepted 22 November 2023, Available online 30 December 2023
DOI: 10.21463/jmic.2023.12.3.11

Abstract

To measure influences of environmental factors and population on Living Tool Diversity (LTD) in 10 islands of Shinan-gun, the number of living tools was determined. Correlation analysis, simple linear regression analysis, and principal component analysis (PCA) were performed. Results showed that coastline length and population were positively related to LTD and thus, island size and human dynamics. PCA results showed that living tools could be classified into four groups and that islands could be classified into three groups. Living tool-environmental biplot showed that: 1) the first group composed of AG tools was related to human dynamics as PO, CL, and IA; 2) the second group composed of FI tools was related to island biogeography as DM and PS; 3) the third group composed of FP tools was related to geographical coordinates as LA and LO; 4) the fourth group composed of TA, CO, BR, FS, PM, and CT had weaker correlations than other groups. Island-environmental biplot showed that: 1) the first group composed of R7 and R9 was related to AG and FP tools; 2) the second group composed of R2 was related to FI tools; and 3) the third group composed of R3, R6, R8, and R10 was related to TA, CO, BR, FS, PM, and CT tools. Regression and PCA models accounted for most of the variation of LTD by population and environmental factors across Shinan-gun islands of South Korea.

Keywords

environmental factors, island biogeography, island region, living tool diversity (LTD), Shinan-gun, Korea

Introduction

Korea's islands are mostly located along its western and southern coasts. The majority of these islands fall under the category of tidal-flat islands (Kim and Hong, 2007; Ihm et al., 2008; Hong, 2012; Je et al. 2014). More to the point, one of the main geographical and topographical characteristics of Korean islands is that they are surrounded by many other islands (archipelago). Therefore, Korean islands boast ecologically and biologically unique characteristics as well as diversity that set them apart from islands in other areas. Local residents have been able to adjust to their environment by making use of organisms found in many islands. This has led them to create a unique island and maritime culture. To this end, the study of island culture requires an astute understanding of not only the ecological basis, biological process, and human activities which become the background for cultural creation, but also interactions between these elements (Whittaker, 1998; Hong, 2012; Ko, 2012).

Part of the variety of Living Tool Diversity (LTD) may be explained by different types and lengths of gradients, particularly when using variables without a direct biological meaning, and by the fact that most studies search for the pattern of one environmental factor at a time without considering other factors simultaneously (Ko, 2012, 2013a, b; Je et al. 2014). In general, most studies show a tendency towards an increase in LTD associated with population and environmental factors as well as with increased environmental heterogeneity. Many responses might have been observed due to interactions between factors including disturbance factors. They might have also been observed due to switches in resource limitation along the gradient. Single gradients may have limitations to provide information on different resources at each end of the gradient. In addition, hump-shaped responses may arise as a consequence of these shifts.

It is clear that the link between population and LTD is widespread and generally strong. This link has been identified as a key component of future LTD research. Conclusions could be made by regression analysis or multivariate analysis rather than experimental evidence, making it easy to tease apart direct and indirect effects of population and environmental factors on LTD and underlying mechanisms (Hong, 2012).

In adjacent islands of the Korean Peninsula, island residents have developed and inherited living and surviving tools related to life of a primitive economic society (Ko, 2016a, b). To establish an island museum collecting materials of life and tools in island areas, a project was proceeded by Institution for Marine and Island Cultures, Mokpo National University in May 2012.

To advance our understanding of LTD patterns along environmental gradients, we emphasize the importance of the following points for 10 islands of Shinan-gun (MacArthur, 2005; Ihm et al., 2008; Ko, 2012):

1. It is important to choose appropriate variables, that is, variables reflecting the amount of population or resource availability, and environmental variables that have direct environmental impact on LTD.
2. It is important to study multidimensional gradients of population and environmental parameters using non-linear regression techniques and interactions. Single regression analyses can easily be confused with other variables. Multivariate ordinations are too common in nature to be omitted in the analysis of LTD. It is also important to study long environmental gradients in order to define the response shape of LTD unambiguously.
3. It is important to clarify whether patterns of LTD could be disaggregated into different environmental types.

2212-6821 © 2023 Institution for Marine and Island Cultures, Mokpo National University.
10.21463/jmic.2023.12.3.11 — https://jmic.online/issues/v12n3/11/

Materials and Methods

We studied LTD of 10 islands in Shinan-gun (Fig. 1): Heuksan-do (R1), Bigum-do (R2), Docho-do (R3), Ui-do (R4), Jaeun-do (R5), Amtae-do (R6), Anjwa-do (R7), Palgeum-do (R8), Imja-do (R9), Jaewon-do (R10) (Hong, 2012; Ko, 2012). Living tools such as Clothing tools (CT), Food storage (FS), Cookware (CO), Food processing (FP), Tableware (TA), Picking mountains (PM), Agriculture (AG), Fishing (FI), Breed (BR) were determined from books and papers (Kim, 1984; Kim 1987; Kim et al. 1987; Ko, 2012, 2013a, b, 2014, 2016a, b). Google maps (2020) for each island were also used.

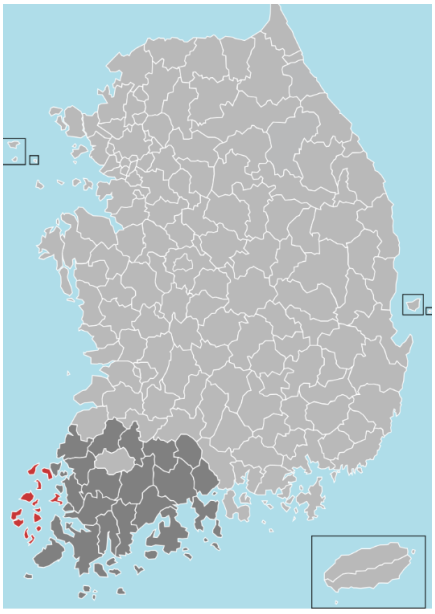

Fig 1. Study area. Red area is Shinan-gun and dark area is Jeollanam-do Province, South Korea.

Environmental factors and population on each island were collected, including Population (PO), Coastline length (CL), Island area (IA), Highest peak (HP), Distance to the mainland (DM), Longitude (LO), Latitude (LA). Correlation and simple regression analyses were employed to measure relative influences of independent variables on living tool diversity. Principal component analysis (PCA) was used to elucidate the relationship between environmental factors and living tool factors and between islands and living tool factors in 10 islands of Shinan-gun.

Table 1. Study islands coastline length and island area at the decimal latitude and longitude coordinates of 10 islands at Shinan-gun in South Korea.

Abbreviation	Island Name	Latitude	Longitude	Coastline length (km)	Island area (km^2)	Highest peak (m)
R1	Is. Imja-do	34.6828	125.4273	59.2	21.7	378
R2	Is. Bigum-do	34.7554	125.9266	86.4	44.1	255
R3	Is. Docho-do	34.7035	125.9534	42.0	41.9	219
R4	Is. Ui-do	34.6115	125.8401	21.0	10.7	359
R5	Is. Jaeun-do	34.8842	126.0474	56.8	52.2	364
R6	Is. Amtae-do	34.8270	126.1120	39.8	29.0	356
R7	Is. Anjwa-do	34.7560	126.1249	49.7	49.0	182
R8	Is. Palgeum-do	34.7850	126.1426	30.3	18.0	159
R9	Is. Heuksan-do	35.084	126.1115	81.0	40.9	320
R10	Is. Jaewon-do	35.0894	126.0233	11.0	5.0	245

Results

The following characteristics were examined for 10 islands of 72 inhabited islands in Shinan-gun (Table 1). Is. Heuksan-do is located in Northwestern part and 90 km away from Mokpo-si. Its coastline length is 42 km. The highest mountain is Mt. Munamsan (405 m above sea level). Most (95%) of the island is evergreen forest. Is. Bigumdo is located in the western part. It is 54 km away from Mokpo-si. The highest mountain is Mt. Seonwangsan (255 m above sea level). Sea cliff was developed with a salt farm in the south coast. Island area of Is. Docho-do is 42 km^2. Its coastline length is 42 km. This island is located 55 km away from Mokpo-si. There is a hill district in the southern part with fields in northern and western parts. Especially, the Goran field is the widest in Shinan-gun. Its coastline is more or less complex than the other islands. It mainly has a rock coast. Is. Uido is located in the southwestern part of Is. Docho-do. Its island area is 11 km^2 with a coastline length of 21 km. There is a long sand coast in the north with beautiful and fantastic rock and precipice in the west coast. Is. Jaeun-do is located in the northwestern part. It is 29 km away from Mokpo-si. Its island area is 52 km^2 with a coastline length of 57 km. It has a sandy coast with sand dune developed in the coast. Is. Amtae-do is located in the western part. It is 25 km away from Mokpo-si. Its island area is 29 km^2 with a coastline length of 40 km. The highest mountain is Mt. Sungbongsan (356 m above sea level). Is. Anjwa-do is located in the western part. It is 21 km away from Mokpo-si. Its island area is 47 km^2 with a coastline length of 50 km. The highest peak is Mt. Bongsan (182 m above sea level). Rice field was developed by sedimentation of littoral current and land reclamation along the east coast. Is. Palgeum-do is located in the west part. It is 19 km away from Mokpo-si. Its island area 17 km^2 with a coastline length of 30 km. The highest peak is Mt. Geumdangsan (130 m above sea level). Its coast is mostly a sandy coast. There are many salt farms in the north coast and the south coast. The island area of Is. Imja-do is 40 km^2 with a coastline length of 81 km. The highest peak is Mt. Daedunsan (320 m above sea level). Is. Jaewon-do is located at the western part of Is. Imjado. Its island area is 5 km^2 with a coastline length of 11 km. The highest peak is Mt. Amisan (244 m above sea level). Its coast is mostly a rock coast.

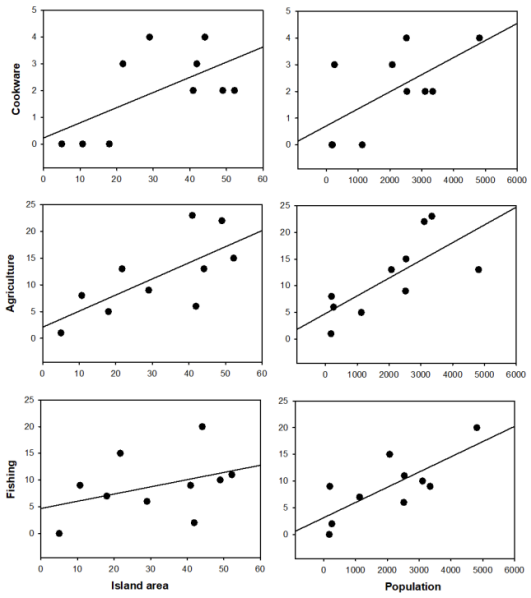

Fig 2. Regression analyses of cookware, agriculture, and fishing against coast length (left) and population (right). All are significant at 5% level.

Table 2. Results of linear regressions of cookware, agriculture, fishing on 2 different explanatory variables (coastline length and population). All regressions are significant at 5% level

Independent variable	Dependent variable	Slope	Intercept	N	r
Coastline length	Cookware	0.0433	-0.069	10	0.672
	Agriculture	0.2185	1.075	10	0.740
	Fishing	0.1786	0.377	10	0.749
Population	Cookware	$6.4x10^{-4}$	0.711	10	0.638
	Agriculture	$3.3x10^{-3}$	4.809	10	0.724
	Fishing	$2.9x10^{-3}$	0.159	10	0.764

Population ranged from 175 to 4515 people, with an average value of 2015 people. Coastline length ranged from 11.0 to 86.4 km, with an average value of 47.7 km. Island area ranged from 5.0 to 52.2 km^2, with average value of 31.3 km^2. The highest peak ranged from 159 to 405 m, with average value of 286 m. Distance to the mainland ranged from 3.1 to 95.0 km, with an average value of 27.2km. Longitude ranged from 125.4273 to 126.1426, with an average value of 125.9709. Latitude ranged from 34.6115 to 35.0894, with an average value of 34.81788. Plant species richness ranged from 109 to 496 species, with an average value of 265 species.

Regression of population, coastline length, and island area had positive influences on the number of cookware, agriculture, and fishing tools. All relationships were statistically significant at the 0.05 level (Fig. 2 and Table 2).

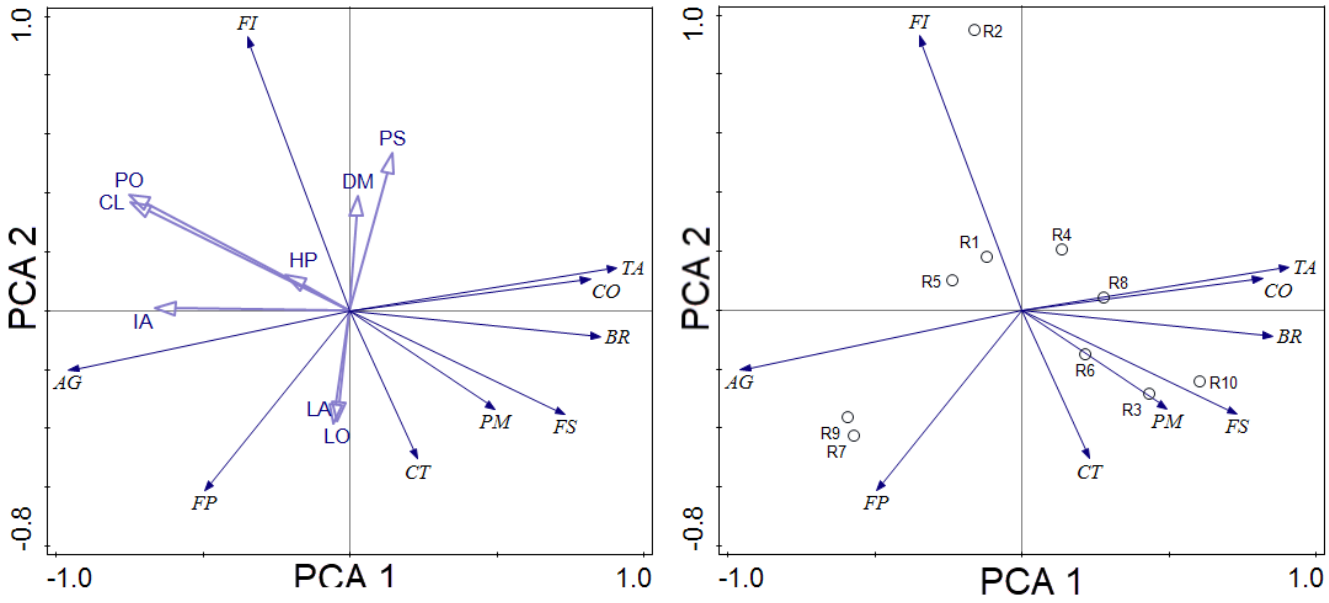

Fig 3. Principal component analysis (PCA) ordination diagrams of living tools. Left: Living tool-environmental biplot. Right: Island-environmental biplot. Full living tool and island names can be found in Materials and Methods.

Figure 3 (left) shows principal component analysis (PCA) bi-plot diagrams of 10 islands of Shin-gun in South Korea. Environmental factors are visualized as arrows. Living tool factors are plotted along axes 1 and 2. They can be classified into four groups. PCA explanatory variables accounted for 84.94% of the variance in living tool data. On PCA axis 1 and axis 2, eigenvalues were 0.5503 and 0.2992, respectively. Figure 3 (right) shows that all 10 islands are evenly distributed on PCA axis 1 and axis 2. They could be classified into three groups, which explained 87.67% of fitted variation with eigenvalues of 0.6914 and 0.1854 for PCA axis 1 and axis 2, respectively.

Discussion

Figure 2 indicates that LTD is related to island size and human dynamics. Figure 3 (left) shows that: 1) the first group composed of AG tools is related to human dynamics as PO, CL, and IA; 2) the second group composed of FI tools is related to island biogeography as DM and PS; 3) the third group composed of FP tools is related to geographical coordinates as LA and LO; and 4) the fourth group composed of TA, CO, BR, FS, PM, and CT shows weaker correlations than other groups. Figure 3 (right) shows that the first group composed of R7 and R9 is related to AG and FP tools, the second group composed of R2 is related to FI tools, and the third group composed of R3, R6, R8, R10 is related to TA, CO, BR, FS, PM, and CT tools.

Comparisons of LTD to several hypotheses are challenging owing to varying natures of proposed explanations and difficulty in evaluating opposing hypotheses within a uniform framework. Urgently needed are big data studies about effects of environmental factors on living tool diversity. Any explanation of broad-scale living tool patterns must account for the ubiquitous and strong diversity-environmental factor correlation.

Principles of island ecology and their influences on insular species richness have been well tested by empirical studies of a number of islands (Kohn and Walsh, 1994; Choi, 2000; Chung and Hong, 2006). Much attention has been given to qualifying environmental factors such as island area, distance from mainland or from other islands, elevation, latitude, and culture (Johnson and Raven, 1973; Whittaker, 1998; Ihm et al., 2008). Terrestrial biota of islands is considered by ecologists as useful natural experiments because they are relatively simple, well defined, and abundant. Meanwhile, island theory has been applied to conservation questions in terrestrial systems comprised of anthropogenic problems or natural habitat patches (Kim et al., 1984; Kohn and Walsh, 1994; Harrison, 1999; Choi, 2000; Ihm et al., 2008).

The presence of certain traditional cultural elements shows that human life has continued within an ecosystem. Moreover, it is possible to draw up cultural plans to actualize environmental conservation and development in the future (Hong 2011a, b; Hong, 2012; Oh et al., 2013; Kim, 2015).

Above all, traditional vocations of residents of Shinan-gun region, namely fishing, agriculture, and the collection of marine products, can be regarded as having an inherent cultural value (Song, 2020). Living tools for collection and fishing, agricultural implements, and indigenous knowledge which have been conveyed to the present have all played a highly efficient role in securing of the resources needed for survival and the preservation of an ecological balance by ensuring minimum human intervention in the natural process (Oh et al., 2013).

Korea's fisheries and aquaculture-related scientific technology have reached the level where it is now possible to revive the unique ecosystem of a regional community and to use such an ecosystem in an environmentally-friendly and ecological manner (Lee, 2020; Song, 2020). Even from the cultural standpoint, human resources and cultural conditions needed to entrench ecological fisheries and aquaculture can be established through governmental and non-governmental organizations efforts to emphasize traditional cultural elements and revive residential structures and norms.

In Shinan-gun, large-scale construction projects have been carried out to link islands to the mainland. However, such projects can eliminate geographical characteristics of islands (Hong, 2011b; Ko, 2012; Ahmed et al., 2015; Kim, 2015). Because islands are being connected to the mainland, a lot of new species from the mainland will have access to islands, posing serious threats to the ecology on islands and eventually causing damage to people living on affected islands. Activities for international cooperation are actively being pursued to solve fundamental environmental problems

such as these connections. Particularly, efforts are being made to preserve and utilize a variety of unique culture native to these islands. A variety of efforts should be made to preserve and take advantage of island culture in sustainable ways. Island culture reflected by changes of LTD has been built through interactions between nature and human beings over a long period of time. To prevent island culture from being undermined, it is certainly necessary to obtain cooperation of residents.

Acknowledgements

This Research was supported by Research Funds of Mokpo National University in 2020.

References

Ahmed, D.A., Fawzy, M., Saeed, N.M., Awad, M.A. 2015. Effect of the recent land use on the plant diversity and community structure of Omayed Biosphere Reserve, Egypt. Glob. Ecol. Cons. 4: 2637.

Choi, S.-W. 2000. Study on the ecological influences on the butterfly fauna of islands in Korea - Roles of island area, isolation, latitude and maximum elevation-. Kor. J. Environ. Bio1. 18: 237-246.

Chung, J.M., Hong, K.N. 2006. Island biogeographic study on distribution pattern of the naturalized plant species on the uninhabited islands in Korea. J. Ecol. Field Bio1. 29: 489-494.

Harrison, S. 1999. Local and regional diversity in a patchy landscape: native, alien, and endemic herbs on serpentine. Ecol. 80: 70-80.

Hong, S.K. 2012. Tidal-flat islands in Korea: Exploring biocultural diversity. J. Mar. Isl. Cult. 1: 11-20.

Hong, S.K. 2011a. Biocultural diversity and traditional ecological knowledge in island regions of Southwestern Korea. J. Ecol. Field Biol. 34 (2), 137–147.

Hong, S.K. 2011b. Eco-cultural diversity in island and coastal landscapes: conservation and development. In: Hong, S.K., Wu, J., Kim, J.E., Nakagoshi, N. (Eds.), Landscape Ecology in Asian Cultures. Springer, Tokyo, pp. 11–28.

Ihm, B.-S., Lee, J.-S., Song, T.-K., Kim, N.-O., Kim, J.-W., Myung, H.-H. 2008. Predictive models of plant species richness per unit area on inhabited islands of South Korea. J. Basic and Life Res. Sci. 8: 12-17.

Je, J.-G., S.K. Hong, J. Kim. 2014. Shapes of fishing gears in relation to the tidal flat bio-organisms and habitat types in Daebu Island region, Gyeonggi Bay. J. Mar. Isl. Cult. 3: 31-40.

Johnson, M.P., Raven, P.H. 1973. Species number and endemism: the Galapagos Archipelago revisited. Science 179: 893-895.

Kim, C.-S. 1984. The flora of Huksan-do Archipelago –Survey in Taehuksan-do. Bulletin of Institute of Littoral Environment, Mokpo National University 1: 67-91.

Kim, C.-S. 1987. Studies on the flora and vegetation of Hong-do. The report of Hong-do natural monument, Jeollanam-do Province Sinan-gun. pp. 107-193.

Kim, C.-S., Jang, Y.S., Oh, C.-G., 1987. Studies on the flora and vegetation of Ui-do. Bull. Inst. Littoral Environ., Mokpo National University. 4: 1-56.

Kim, J.E., S.K. Hong, 2007. Understanding of islands in the landscape ecological aspect: theory and application of island biogeography. J. Island Cult., 30: 39-54.

Kim, J.E., 2015. Rural landscape and biocultural diversity in Shinan-gun, Jeollanam-do, Korea. J. Ecol. Environ., 38(2): 249-256.

Kim, J.H., Chang, S.M., Lee, H.J., 1984. The Vegetation of Kokum Island. Korean J. Eco1., 7: 132-157.

Ko, K.M., 2012. Life and Tools in Heuksan-do Islands. Minsokwon, Seoul.

Ko, K.M., 2013a. Life and Tools in Island Residents 2 - Bigum-do, Suchi-do, Docho-do, Ui-do. Minsokwon, Seoul.

Ko, K.M., 2013b. Life and Tools in Island Residents 3 - Jaeun-do. Minsokwon, Seoul.

Ko, K.M., 2014. Life and Tools in Island Residents 4 - Jaeun-do, Amtae-do, Chupo-do. Minsokwon, Seoul.

Ko, K.M., 2016a. Life and Tools in Island Residents 5 - Anjwa-do, Palgeum-do, Jara-do, Sachi-do. Minsokwon, Seoul.

Ko, K.M., 2016b. Life and Tools in Island Residents 6 - Imja-do, Jaewon-do, Su-do, Bunam-do. Minsokwon, Seoul.

Kohn, D.D., Walsh, D.M. 1994. Plant species richness - the effect of island size and habitat diversity. J. Ecol., 82: 367-377.

Lee, K.A., 2020. Islands and Agriculture. In: Institution for Marine and Island cultures, Mokpo National University (Eds.), The 15 Key Words for Understanding Islands. Jeonnam, Muan-gun. pp. 86-121.

MacArthur, R.T. 2005. Factor influencing vascular plant diversity on 22 islands off the coast of eastern North America. J. Biogeogr., 32: 475-492.

Song, K.T. 2020. Islands and Fishing. In: Institution for Marine and Island cultures, Mokpo National University (Eds.), The 15 Key Words for Understanding Islands. Jeonnam, Muan-gun. pp. 124-129.

Oh, K.H., Chung, C.H., Hong, S.K., Kang, B.Y., Kim, J.E., 2013. The plan for evaluation and use of geomorphology, geology and landscape of tidal flat island at Shinan-gun, Jeollanamdo. J. Korean Island, 25: 187-203.

Whittaker, R.J., 1998. Island biogeography: ecology, evolution, and conservation. Oxford University Press, Oxford.